Department of Environment
and Resource Management

Mapping of environmental characteristics important for Reef water quality

Wet Tropics priority catchment

Assessment methodology

August 2011

Prepared by: Land Resource Assessment, Department of Environment and Resource Management

Citation

DERM (2011) 'Mapping environmental characteristics important for GBR water quality: Wet Tropics – Assessment methodology', Brisbane: Department of Environment and Resource Management, Queensland Government.

August 2011

ISBN 978-1-7423-0941

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Introduction

The Queensland Government through the Reef Protection Package has introduced legislation—supported by research, extension and education activities—to reduce the level of sediment, nutrients and pesticides (contaminants) leaving commercial sugarcane properties >70 ha and cattle grazing properties >2000 ha within priority catchments (Wet Tropics, Burdekin and Mackay–Whitsunday). The amounts of these contaminants reaching the Great Barrier Reef (GBR) have increased substantially since European settlement and are now recognised as posing a serious threat to the long-term viability of the GBR. Not all parts of the landscape contribute equally to this problem—initial water quality modelling has already identified some GBR sub-catchments contribute much more than others. This uneven distribution of contributions from across the landscape can be attributed in part to differences in land use and land management practices. However, areas with similar land use and land management may contribute varying amounts of contaminants depending on their natural features (‘environmental characteristics’).

The aim of the Reef Protection Package in the priority catchments is to encourage the adoption of land management practices that reduce contaminant loads moving off-property. In order to effectively support sugarcane growers to adopt risk-based management, DERM is coordinating a range of projects focused on answering the following questions:

1. What and where are the environmental characteristics that predispose landscapes to contribute above-natural levels of sediment and deliver nutrients and herbicides offsite through water movement?
2. What systems/practices are being used on sugarcane and grazing properties to manage environmental characteristics?
3. Within the priority catchments, what and where are the main risks associated with sugarcane and grazing activities?
4. What are the management systems that should be adopted to minimise risk?
5. What information on environmental characteristics could be provided to assist landholders in determining appropriate practices to minimise movement of contaminants off-site?

This project identifies and maps the natural features (‘environmental characteristics’) that predispose landscapes to contribute to GBR water quality decline. Outputs of this project will assist in addressing questions 1 and 5 above. Further studies of other parts of the GBR catchments (e.g. grazing in the Burdekin catchment) are ongoing.

Four environmental characteristics are detailed in this report:

- Soil erosion potential (i.e. the inherent potential of soil to erode according to slope and soil features)
- Flooding frequency (i.e. the flooding regime of landscapes that may transport contaminants to watercourses)
- Water pathway (i.e. the potential of soils to generate runoff which can mobilise and transport contaminants)
- Soil transport potential (i.e. the inherent potential for soil fractions to be transported long distances).

In addition to this report, outputs of the project also include:

- Spatial data sets for the four environmental characteristics across Wet Tropics priority catchment; and
- A user guide, which assists users to understand and interpret the environmental characteristic maps.

In using this information it is important to be aware of its context. Environmental characteristics of an area indicate whether land is predisposed to contribute contaminants to surface waters. The extent to which contamination actually results will depend on how the land is used, and the management activities applied to it. The conceptual framework which describes the interaction between the natural environment and land management in determining landscape behaviour is illustrated in Figure 1.

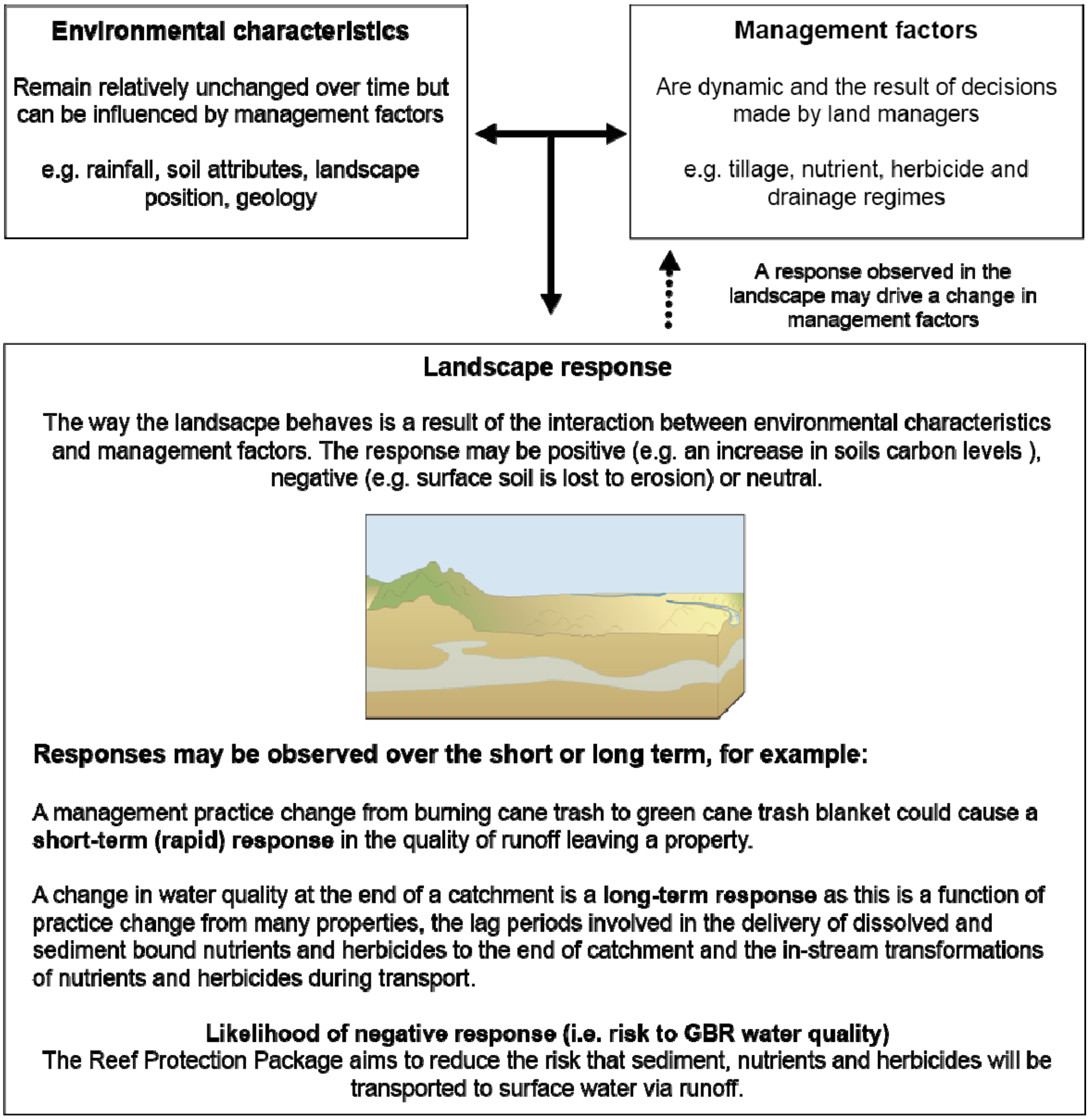


Figure 1. Conceptual overview showing the interaction between environmental characteristics, management activities and landscape response.

As illustrated above, it is important that environmental characteristic information is considered in parallel with land management to determine the likelihood that sugarcane production systems will impact on water quality. The availability of current spatial information on sugarcane management systems is limited, however this data is being collected as part of the DERM Paddock to Reef Integrated Monitoring, Modelling and Reporting Program and the Reef Protection Package.

Once information about management systems is available, there is the potential to combine the spatial data sets for environmental characteristics and management systems in order to identify areas that present a higher risk to the GBR. This information could be used to more effectively target extension and investment activities of the Reef Protection Package and ensure that growers in areas of higher risk receive support to adopt management systems appropriate to their local conditions.

Users of environmental characteristic maps should also be aware of the intended use of these maps. Environmental characteristic maps can assist users to understand the variability and general features of soils found across cane farms (e.g. farms of 50 hectares or greater). However, these maps do not precisely identify the location of soil boundaries and cannot support detailed property planning, e.g. precision agriculture. The user guide that accompanies this technical report provides further information about how the maps can support identification of general property features, for example as part of desktop assessment processes.

Project scope

This project was undertaken to:

1. Provide a source of information on the natural landscape features (or environmental characteristics) that influence movement of contaminants off-property via surface water transport processes[1].
2. Present the analysis in a way that is easily understood by landholders, extension officers and Reef Protection Officers.

Project area

The project area is delineated by the Wet Tropics priority catchment area as detailed in Chapter 4A of the *Environmental Protection Act 1994*. The project area and the extent of sugarcane land use is displayed in Figure 2. The sugarcane land use extent was developed by combining the land use data captured between 1999 and 2004 in the Wet Tropics (DERM 2006). Sugarcane growing occurs mainly on the alluvial soils of the narrow coastal plain east of the Great Dividing Range, with some additional production areas on its steeper slopes and the tablelands. Climate classification based on the Köppen system (Stern *et al.* 1999) delineates subtropical and tropical climate groups across the project area (Figure 3).

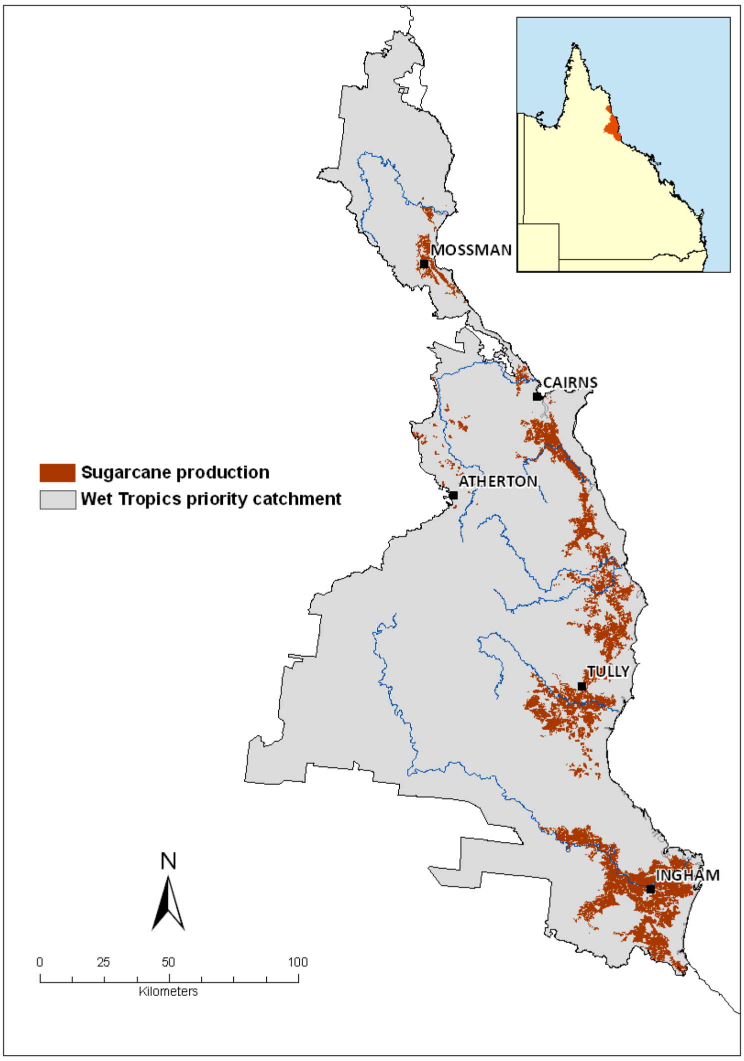


Figure 2. Extent of sugarcane production in the Wet Tropics priority catchment (DERM 2006)

[1] While it is recognised that groundwater processes are also important for GBR water quality, this report does not consider the vulnerability of landscapes to transport contaminants via groundwater.

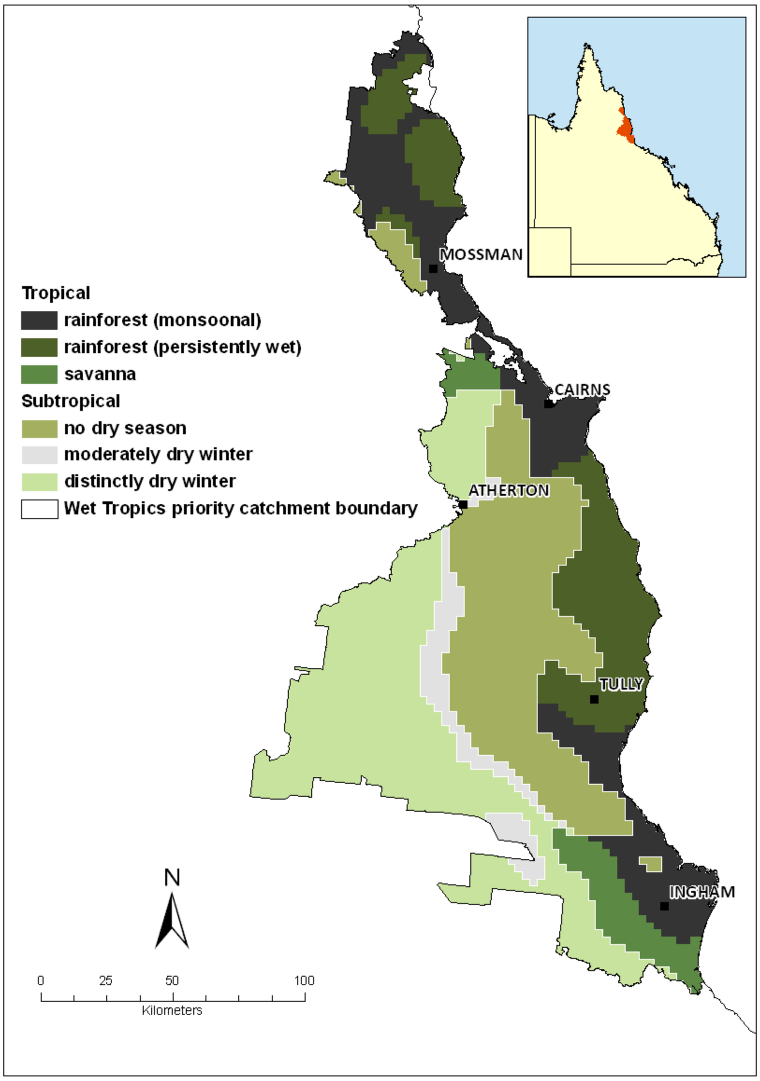


Figure 3. Köppen climate zones for the Wet Tropics priority catchment

Project methodology

Stage 1

The major threat identified to GBR water quality from sugarcane production in the Wet Tropics catchment is from the transport of excess nutrients and pesticides off-property (Brodie *et al.* 2008). Although elevated sediment loads have been linked to sugarcane production in the Wet Tropics (Hateley *et al*. 2007), loads are relatively small compared to those from catchments such as the Burdekin (Faithful *et al.* 2007). A conceptual model was developed to describe how the contaminants travel from land to the GBR, in order to identify the environmental characteristics that support contaminant movement. Nutrients and pesticides are primarily transported to waterways via water movement. Water can erode landscapes and transport contaminants in soluble form as well as those in insoluble forms that are attached to soil particles (Finalyson & Silburn 1996). Therefore environmental characteristics relevant to GBR water quality are those inherent landscape features that promote soil and water movement. A range of relevant environmental characteristics and available data sets were initially identified and assessed for suitability of use. Appendix A presents a list of all data sets considered and the rationale for inclusion or exclusion of each data set.

The environmental characteristics that can be represented by available data sets include erosion potential, flooding frequency, water pathway (runoff potential) and soil transport potential.

Stage 2

The second stage of the project entailed the following components:

- Peer review process
- Field validation of information products.

A technical workshop was held to assess the appropriateness of the project methodology and information products from Stage 1. This workshop involved scientists and natural resource managers with expertise relevant to the project area (refer to stage 3 below for a brief summary of workshop outcomes).

Broad-scale field validation was carried out for the water pathway and soil transport potential data sets. Field validation sites were selected in a variety of soil—landscape settings (Figure 4). At each site, the data on surface soil texture and expected dominant water pathway was compared to field results for these attributes. There were no contradictions between data used for the final products and results determined in the field. It was beyond the scope of this assessment to validate the land resource data used for erosion potential and flooding as the data was captured at a finer scale and broad-scale validation is not sufficient to do this accurately. This is not a concern however, as the original land resource survey method included a data validation component.

Stage 3

The third and final stage of the project used the outcomes of the peer review process and field validation to refine data sets and maps for the four environmental characteristics of erosion potential, flooding frequency, water pathway and soil transport potential. For example, the terminology used in this report and the maps has been updated following discussion at the workshop. Finer scale data sets were also investigated for potential use, but were unable to be incorporated due to inconsistencies in data collected (refer to ‘Limitations of mapping’ section for further information). The influence of other characteristics (e.g. rainfall, vegetation cover and drainage networks) in determining water quality has also been incorporated as contextual information in the user guide.

The four environmental characteristics are described in the following sections.

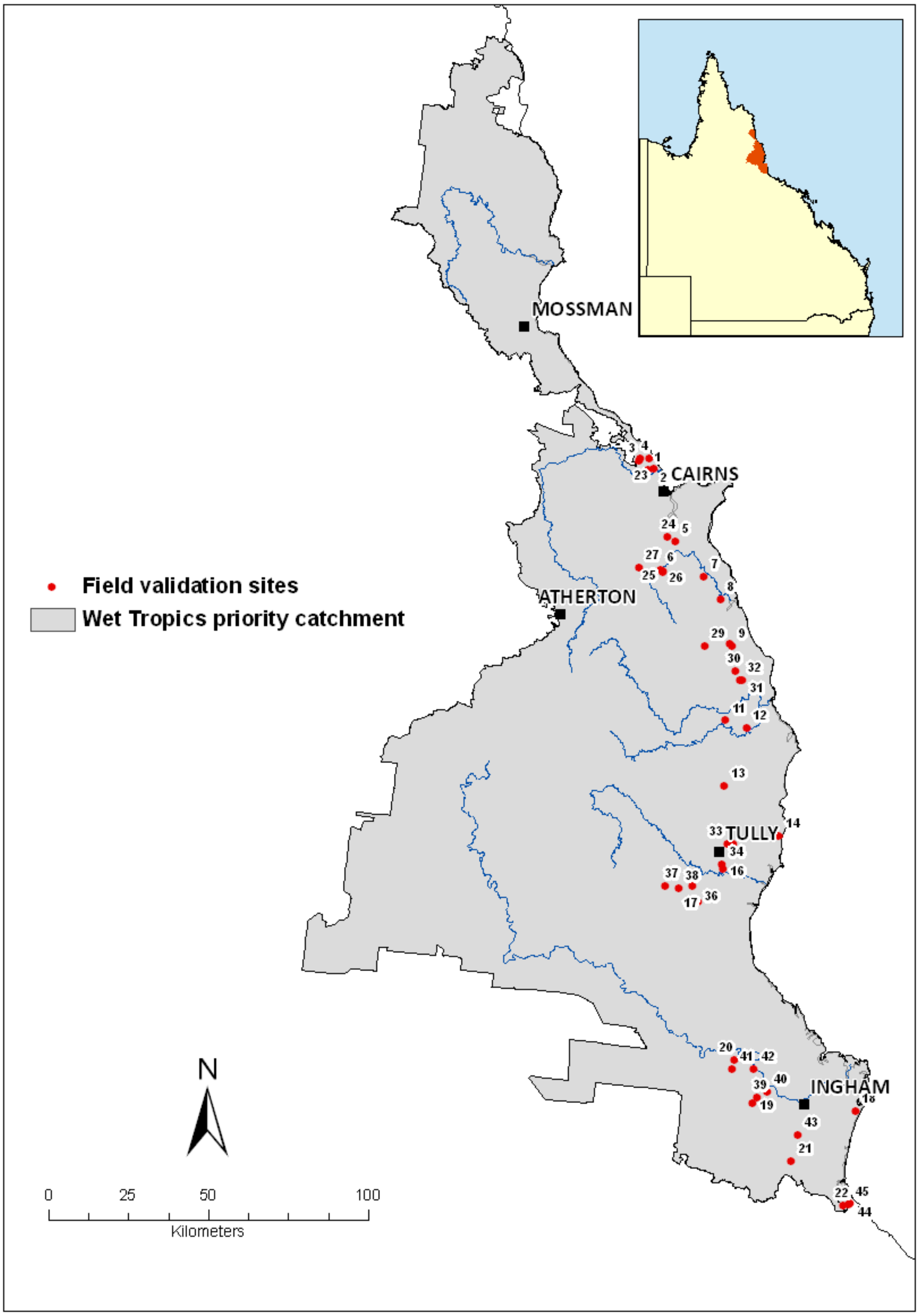


Figure 4. Sites visited for field validation of water pathway and soil transport potential data sets during stage 2 of the project.

Environmental characteristics described

Erosion potential

The erosion potential of the landscape is a fundamental characteristic in determining soil movement. In the Wet Tropics, hillslope and streambank erosion are the dominant processes contributing sediment to watercourses. There are currently no data to map streambank erosion. The erosion potential from hillslope erosion processes (i.e. rill, sheet and scald) is described during land resource surveys and assessed according to slope (which can increase the velocity of runoff), and the natural erodibility of the soil. The erosion potential layer in this assessment has been developed from these data. The soils with the highest potential to contribute to sediment loss are those which are erodible on steep slopes.

Flooding frequency

The majority of contaminants that reach the GBR are delivered during flooding events (Brodie *et al.* 2008). The timing and magnitude of the first flood event is particularly important due to the 'first flush' phenomenon in floodplain environments. The first flood typically contains larger contaminant loads, likely due to the mobilisation of contaminants that have accumulated both on the land surface and within watercourses (Wallace *et al*. 2009). Floodwaters moving through sugarcane production areas may mobilise contaminants and transport these to the GBR. There is a greater potential for floodwaters to transport soluble nutrients and pesticides to the GBR, due to limited trapping opportunities. Timing and method of nutrient and pesticide application is therefore important in environments that frequently flood. Information on flooding frequency and extent is derived from data collected during land resource surveys.

Water pathway

Landscapes that are prone to generating runoff are more likely to facilitate the movement of sediment, nutrient and pesticides, as runoff provides the media for entrainment and transport. Runoff is generated as a result of rainfall rate exceeding the rate of infiltration (infiltration excess) or the soil reaching saturation and therefore being unable to store any additional rainfall (storage excess) (Finlayson & Silburn 1996). The water pathway matrix represents the storage excess model by considering the soil characteristics of permeability and drainage, as described during land resource surveys (Appendix 5). As soil permeability and drainage decrease (i.e. soils are less permeable and poorly drained), the likelihood of runoff increases.

Soil transport potential

Clay particles (< 0.002 mm) are the smallest primary soil particles and are more easily transported long distances by water than silt and sand particles. As a result, soils with high water-dispersible clay content have a higher potential to be transported further and are more likely to reach the GBR. Because water dispersible clay contents are not available for the soils in the Wet Tropics catchment, surface soil texture has been used in this report as an indicator of soil transport potential. The relative proportion of primary particles (sand, silt, clay) in the surface soil can be inferred from surface soil texture as described in the field during land resource surveys. It is assumed that the higher the clay content of the soil, the more likely it is to contribute clay-sized particles in runoff, and this characteristic is used to identify soils with higher transport potential. Furthermore, soils with high clay content are also more likely to bind to nutrients and pesticides, due to the negative charge of clay particles (Finlayson & Silburn 1996, Hunter & Walton 2008, Faithful *et al.* 2007).

Data sets

The reference and description for data sets used to represent environmental characteristics are outlined in Table 1.

Table 1. Data sets used to represent each environmental characteristic.

Environmental characteristic	Dataset reference	Data description
Erosion potential	Soil and Land Information (SALI) database, DERM, Brisbane. (DERM 2010). For a complete list of the land resource information utilised in this assessment see Appendix B.	This data describes erosion potential based on soil type and slope as specified during land resource surveys. It refers to hillslope (rill, sheet and scald) erosion processes; it does not describe streambank or gully erosion potential. This data was derived from land resource surveys focused on areas suitable for intensive agricultural production and therefore erosion potential data is limited to these areas.
Flooding frequency	SALI database, DERM, Brisbane. (DERM 2010).	This data describes the extent and frequency of flooding events. The information is collected during land resource surveys and contained in the SALI database. This data was derived from land resource surveys focused on areas suitable for intensive agricultural production and therefore flooding data is limited to these areas.
Water pathway	Brough DM, Claridge J, & Grundy MJ (2006) *Soil and landscape attributes: A Report on the Creation of a Soil and Landscape Information System for Queensland*, Natural Resources, Mines and Water, Brisbane. QNRM06186. Moody PW & Cong PT (2008) 'Soil Constraints and Management Package (SCAMP): guidelines for sustainable management of tropical upland soils', *ACIAR Monograph* No. 130, 86pp.	This data is derived by combining drainage and permeability soil attributes which are collected during land resource surveys. The drainage and permeability data is interpreted from information contained in the SALI database as per Brough *et al.* (2006). The decision matrix to identify either runoff or drainage landscapes is defined by Moody and Cong (2008) and described in Appendix C
Soil transport potential	Brough DM, Claridge J, & Grundy MJ (2006) *Soil and landscape attributes: A Report on the Creation of a Soil and Landscape Information System for Queensland*, Natural Resources, Mines and Water, Brisbane. QNRM06186. (Brough *et a.l* 2006)	This data describes the generalised soil texture of the surface horizon in terms of sand, loam or clays. The data is interpreted from information in DERM's Soil and Land Information (SALI) database as per Brough *et al.* (2006). Appendix D outlines the specific soil texture that is allocated within each category (sand, loam or clay).

Limitations of mapping

It is important to outline limitations associated with the data used as this influences the confidence and accuracy of environmental characteristic maps. Data limitations are primarily associated with historical database management and the scale at which data are captured.

The major concern for data quality in this assessment is historical database management. Land resource information that DERM holds is stored in the Soils and Land Information (SALI) database. An inventory of historical data in SALI was undertaken to support this project. This inventory revealed data gaps, some of which were able to be remedied by making sure that all existing land resource data had been entered into SALI. This process also identified genuine gaps in current data, where information did not exist for particular soil types. These gaps then became the focus for a field data collection program (including detailed soils descriptions and laboratory analysis). Results from this field program will be incorporated into SALI and updated environmental characteristic maps and spatial data will be available shortly thereafter. Improving the quality of data in SALI will benefit all projects that use this data.

The scale at which the land resource data is collected (cartographic scale) can be another limitation. The cartographic scale is primarily determined by the density of observations, i.e. sampling sites undertaken within a measured area (Table 2). Attendees at the technical review workshop agreed that detailed land resource studies (i.e. scales of 1:50 000 or finer) can support assessment of environmental characteristics at the farm level for intensive land uses, such as sugarcane production. The data within sugarcane production areas of the Wet Tropics are mostly at this level of detail (Figure 5). The exception is the land resource mapping in the Ingham area (at a scale of 1:100 000), however this study was undertaken after considerable knowledge of the area had been attained through other land resource studies. Fewer observations were therefore necessary to map this area accurately and the mapping is considered of a quality similar to that of finer scale studies to the north even though the cartographic scale is 1:100 000.

It is also acknowledged that there are finer-scale soils data within the project area. This data has not been included within this assessment because it is not available in a consistent format, it only covers a small area, and does not include the attributes being assessed (i.e. erosion, flooding, permeability, drainage, texture).

Table 2. Correlation between survey scale and site inspection density (McKenzie *et al.* 2008).

Survey scale	Site inspection density
1:2 500	>4 sites per ha
1:10 000	1 per 0.8 ha
1:25 000	1 to 5 per 25 ha
1:50 000	1 to 5 per 100 ha
1:250 000	<1 per 100ha

NOTE: The user guide that accompanies this technical report explains how environmental characteristic maps should be used to support identification of property features, given the scale at which land resource data is collected.

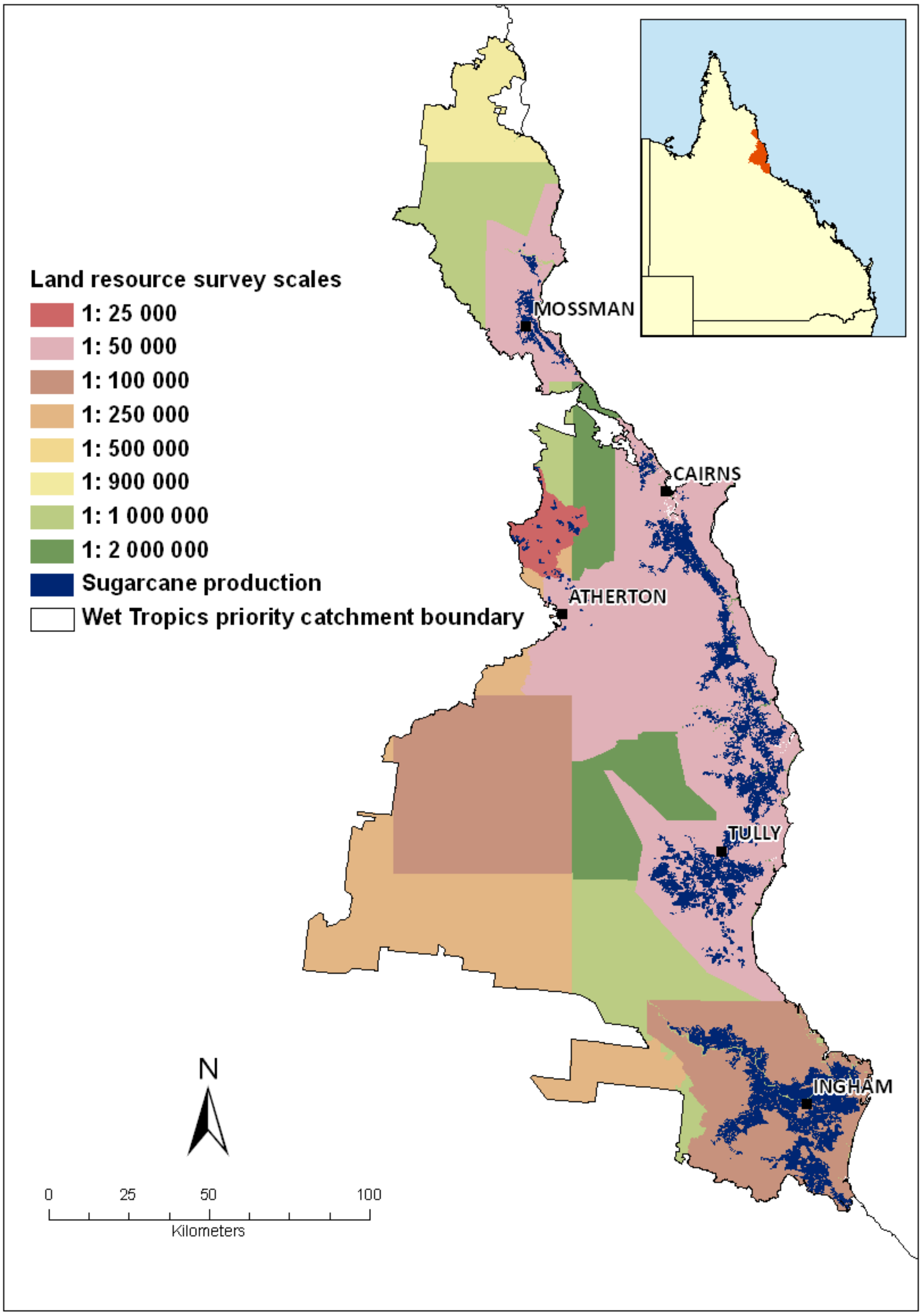


Figure 5. Scale of land resource mapping in Wet Tropics priority catchment (DERM 2010). Linear distinctions between mapping scales represent boundaries of different land resource mapping projects.

Environmental characteristic maps

The maps presented in this report incorporate the improvements facilitated through field validation, peer review and database improvements. Each environmental characteristic is displayed in a separate map. Data has not been combined to produce a single overlay map because it is extremely difficult to generalise the relative importance of individual characteristics in different locations. Each map must therefore be considered separately.

Boundaries between land resource survey projects are distinctly evident as linear features in the data and maps. As a consequence of these boundaries, variations in soil type may appear linear on the map, when in fact the soils are more likely to change continuously and gradually across the landscape. These edge anomalies are inevitable when using information from land resource surveys with distinct survey boundaries and different scales of mapping.

Erosion potential

The erosion potential data indicates the inherent susceptibility of landscapes to generate erosion. However, the likelihood of soil eroding is largely dependent on land management practices. Hence, soils that are naturally prone to erosion may not actually erode under good land management practices and, conversely, soils with a low erosion potential may erode under poor management practice.

The data on erosion potential are drawn from land resource studies where the effect of erosion on agricultural productivity was assessed by considering slope (which can increase the velocity of runoff), and the natural erodibility of soils. These land resource studies were focused on areas suitable for intensive agricultural production and therefore these data are limited to these areas. The highest erosion potential exists where inherently erodible soils occur on steep slopes. The attributes that contribute to each category of erosion potential are detailed in Table 3 and the spatial extent of these categories in the Wet Tropics priority catchment is shown in Figure 6.

There are a few distinct features of the Wet Tropics landscape that have been taken into consideration when assessing erosion potential. Certain areas which would normally be considered too steep for agriculture (i.e. slopes > 15%) have been included, as sugarcane has been observed in some of these areas in the Wet Tropics. Where steep slopes are cultivated for sugarcane, this predominantly occurs on red basaltic soils (Ferrosols) associated with volcanic landscapes along the Great Dividing Range. Ferrosols have well developed soil structure, and this physical property results in these soils being less erodible than other soils on similar slopes. This observation has been taken into account in the allocation of soil and slope attributes into erosion potential categories.

Table 3. Categories for erosion potential.

Category	Description of soil and slope[1] attribute
Lower potential	< 2% slope for granitic soils or < 3% slope for basaltic and metamorphic soils
	3–8% slope, basaltic or metamorphic soils
	< 1.5% slope, cracking clays and imperfectly to poorly drained non-cracking clay soils, podzolics, earths and soils with sodic B horizons at >40 cm
	1.5– 4% slope, cracking clays and imperfectly to poorly drained non-cracking clay soils, podzolics, earths and soils with sodic B horizons at >40 cm
	< 2% slope, granitic soils/well to moderately drained alluvial soils/red-brown clays (excludes texture contrast soils)
	2–5% slope, granitic soils/well to moderately drained alluvial soils/red-brown clays (excludes texture contrast soils)
	< 2% slope, other soils (texture contrast/soils with sodic B horizons at < 40 cm)
	< 5% slope, shallow/skeletal soils/imperfectly to poorly drained soils
	Miscellaneous water map units
	Miscellaneous Urban
	Unclassified land other
Moderate potential	8–15% slope, basaltic or metamorphic soils
	15–20% slope, basaltic or metamorphic soils
	20–30% slope, basaltic or metamorphic soils
	4–6% slope, cracking clays and imperfectly to poorly drained non-cracking clay soils, podzolics, earths and soils with sodic B horizons at >40 cm
	> 6% slope cracking clays and imperfectly to poorly drained non-cracking clay soils, podzolics, earths and soils with sodic B horizons at >40 cm
	2–4% slope, other soils (texture contrast/soils with sodic B horizons at < 40 cm)
	4–6% slope, other soils (texture contrast/soils with sodic B horizons at < 40 cm)
	6–8% slope, other soils (texture contrast/soils with sodic B horizons at < 40 cm)
	5–8% slope, granitic soils/well to moderately drained alluvial soils/red-brown clays (excludes texture contrast soils)
	8–12% slope, granitic soils/well to moderately drained alluvial soils/red-brown clays (excludes texture contrast soils)
	12–20% slope, granitic soils/well to moderately drained alluvial soils/red-brown clays (excludes texture contrast soils)
	5–8% slope, granitic soils/well to moderately drained alluvial soils/red-brown clays (excludes texture contrast soils) in the MDIA area
	8–15% slope, granitic soils/well to moderately drained alluvial soils/red-brown clays (excludes texture contrast soils) in the MDIA area
	5–10% slope, shallow/skeletal soils/imperfectly to poorly drained soils
	10–15% slope, shallow/skeletal soils/imperfectly to poorly drained soils
	> 15% slope, shallow/skeletal soils/imperfectly to poorly drained soils
	MDIA* steep dissected gullies
	Miscellaneous mining quarry units
Higher potential	> 30% slope, basaltic or metamorphic soils
	> 8% slope, other soils (texture contrast/soils with sodic B horizons at < 40 cm)
	> 20% slope, granitic soils/well to moderately drained alluvial soils/red-brown clays (excludes texture contrast soils)
	10–14% slope, granitic soils (excludes texture contrast soils) WTC only
	> 14% slope, granitic soils (excludes texture contrast soils) WTC only
Not assessed	Miscellaneous mountains
	MDIA* steep dissected hills
	Stream channel

*Mareeba Dimbulah Irrigation Area – Soil Sheets

[1] Each slope class was analysed separately, therefore they are not grouped together within each category of erosion potential.

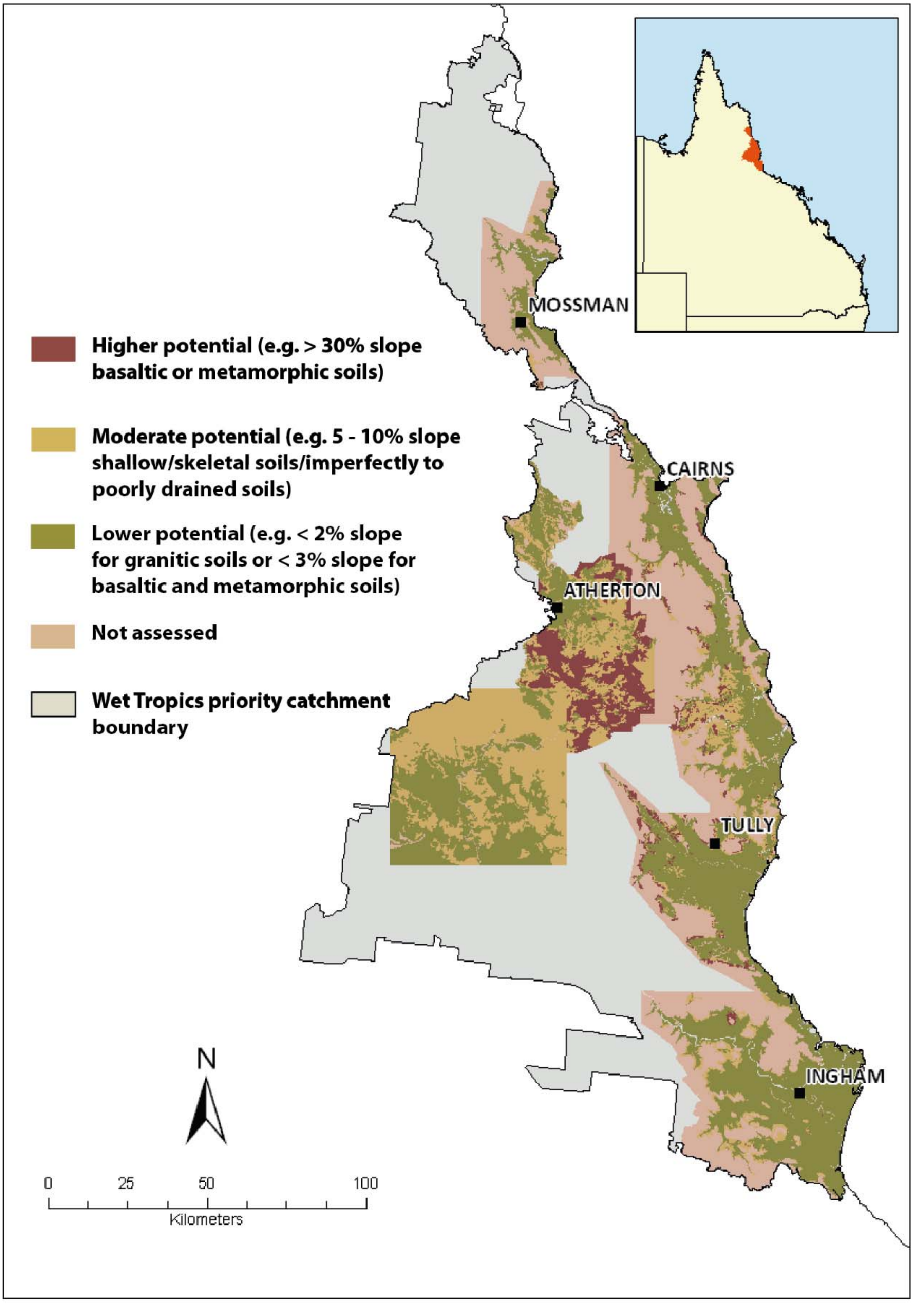


Figure 6. Erosion potential for the Wet Tropics priority catchment.

Flooding frequency

Where sugarcane land use occurs in frequently flooded environments, there is a higher potential for contaminants (particularly soluble forms) to be transported to watercourses. This assessment uses the flooding frequency attribute described during land resource surveys to indicate areas that have a higher potential to transport contaminants (particularly recently applied nutrient or herbicide) via floodwaters. These land resource studies were focused on areas suitable for intensive agricultural production and therefore these data are limited to these areas.

Table 4 describes the flooding frequency categories, and Figure 7 shows the extent and frequency of flooding across the Wet Tropics priority catchment.

Table 4. Categories for flooding frequency.

Category	Description
Moderate flooding frequency	Flooding frequency of 1 in 2 to 1 in 10 years, e.g. levees, backswamps and some higher channel benches
High flooding frequency	Flooding reaches almost annual occurrence, e.g. lower channel benches

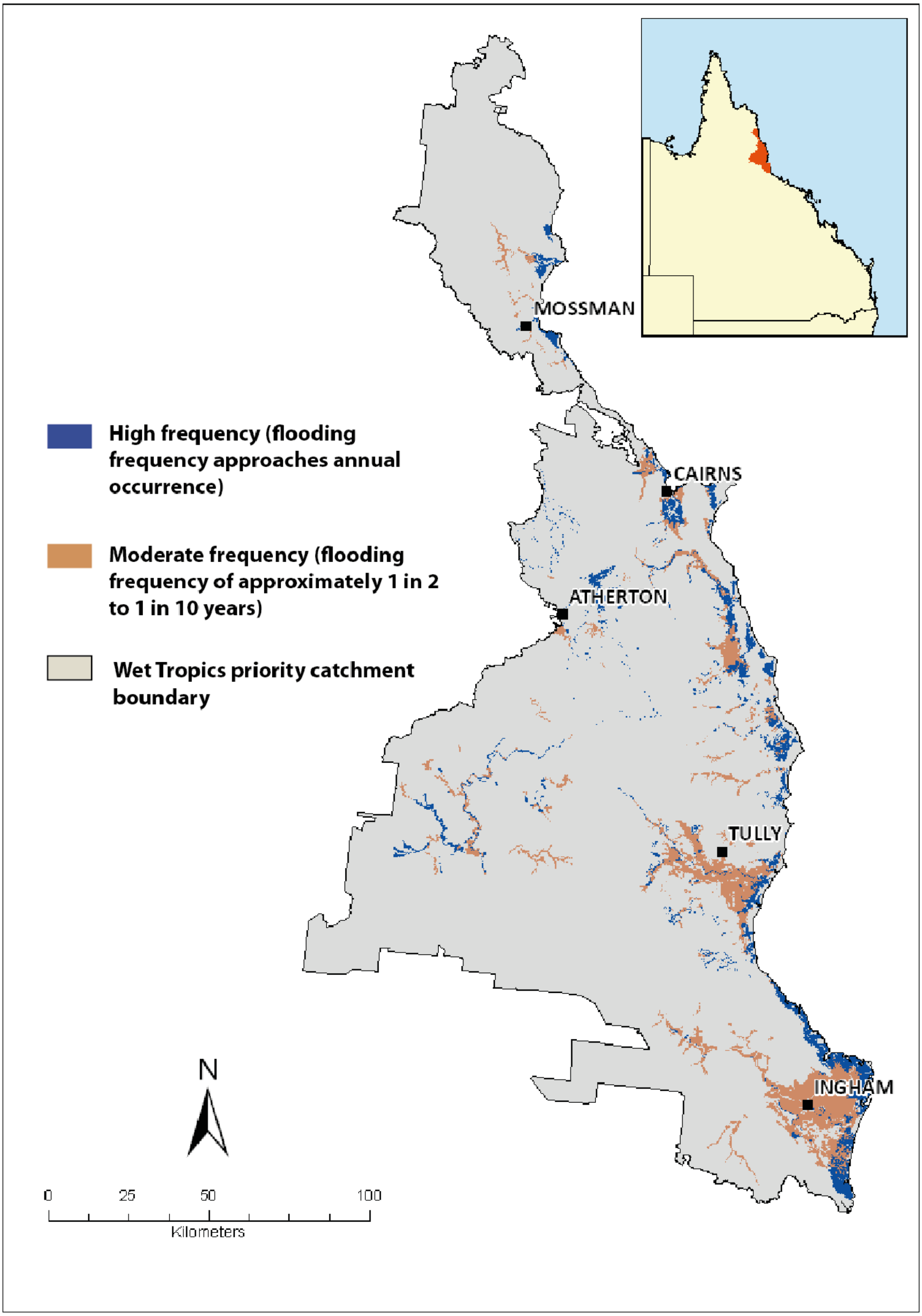


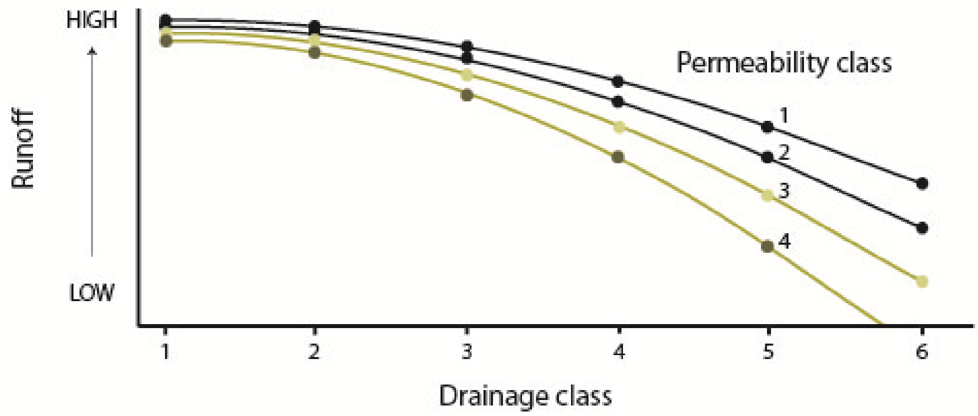
Figure 7. Flooding frequency for the Wet Tropics priority catchment.

Water pathway

Landscapes that are prone to generating runoff are more likely to facilitate the movement of contaminants as water provides the medium for entrainment and transport. The relationship between soil permeability and drainage determines the potential for a soil to generate runoff (Figure 8). For example, as soil permeability and drainage decrease (i.e. soils are slowly permeable and poorly drained), the likelihood of generating runoff increases.

This assessment combines the drainage and permeability characteristics of soil profiles to produce a water pathway matrix, as detailed in Moody and Cong (2008). The water pathway matrix groups soils into three categories, which indicate whether a soil will predominantly facilitate drainage or generate runoff. The classification of water pathway categories is summarised in Table 5 and the dominant water pathway for the Wet Tropics priority catchment is mapped in Figure 9.

Appendix C details the matrix used to derive the dominant water pathway, as well as drainage and permeability class definitions.



Permeability classes
1 – very slowly permeable
2 – slowly permeable
3 – moderately permeable
4 – highly permeable

Drainage classes
1 – very poorly drained
2 – poorly drained
3 – imperfectly drained
4 – moderately well drained
5 – well drained
6 – rapidly drained

Figure 8. Runoff generation can be inferred from soil permeability and drainage classes (adapted from Moody & Cong 2008).

Table 5. Categories for dominant water pathway and corresponding soil permeability and drainage characteristics.

Category	Soil permeability and drainage characteristics
Drainage	Highly permeable and well drained soils have a lower potential to generate runoff.
Runoff and/or drainage	Permeable and imperfectly drained soils have a moderate potential to generate runoff.
Runoff/ponding	Poorly drained and slowly permeable soils have a greater potential to generate runoff.

NOTE: Although this assessment does not address groundwater transport of nutrients and pesticides, this may be inferred by considering parts of the landscape that are prone to facilitate drainage from the water pathway layer.

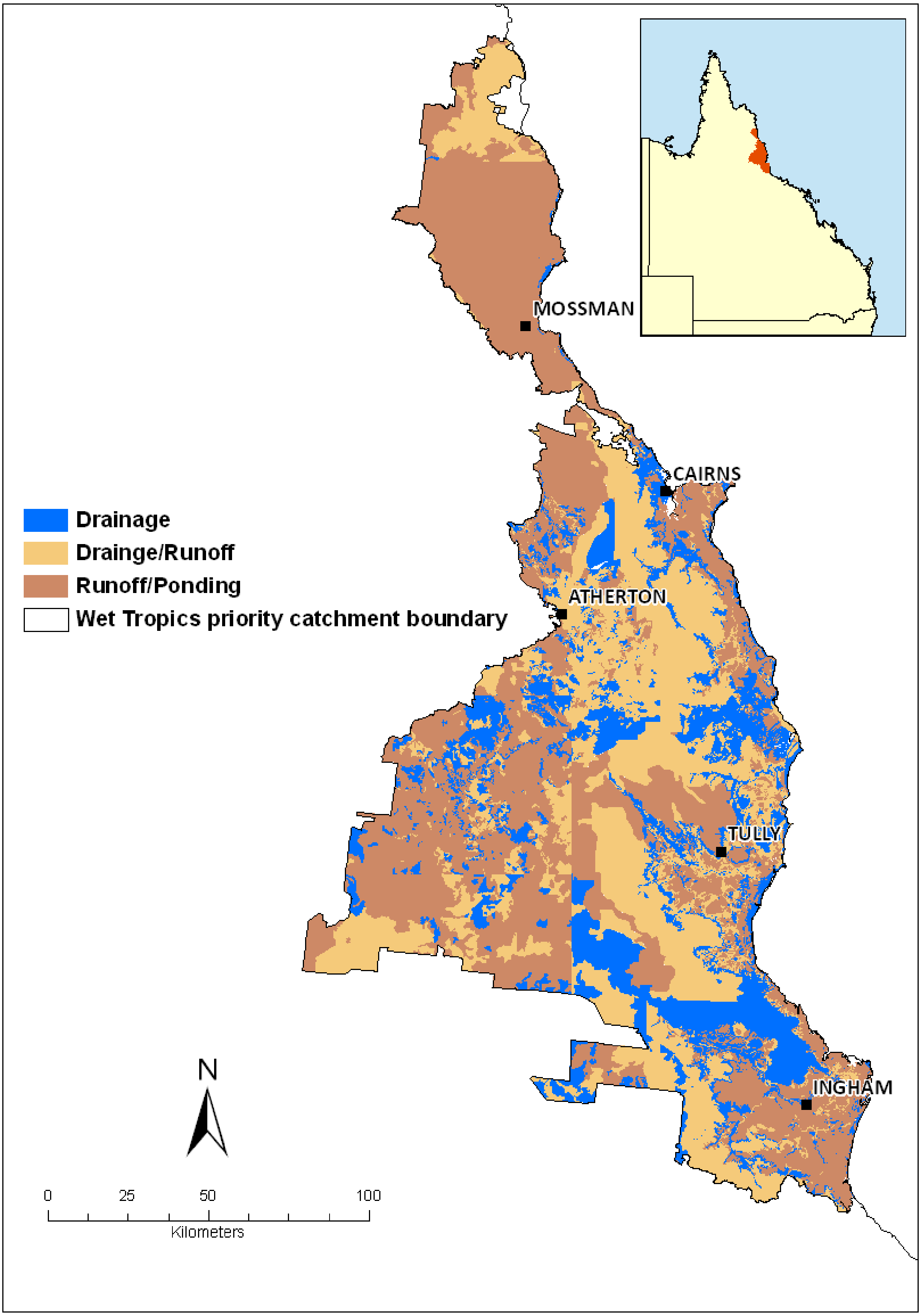


Figure 9. Water pathway for the Wet Tropics priority catchment.

Soil transport potential

Clay particles (< 0.002 mm) are the smallest primary mineral soil particles and are more easily transported long distances by water than silt and sand particles. As a result, soils with high water–dispersible clay content have a higher potential to be transported further and are more likely to reach the GBR. Because water dispersible clay contents are not available for the soils in the Wet Tropics catchment, surface soil texture has been used in this report as an indicator of soil transport potential. It is assumed that the higher the clay content of the soil, the more likely it is to contribute clay-sized particles in runoff, and this characteristic is used to identify soils with higher transport potential. Furthermore, soils with high clay content are also more likely to bind nutrients and pesticides, due to the negative charge of clay particles. The higher surface area of clays can also increase the capacity to transport nutrients and pesticides.

This assessment uses the surface soil texture attribute described during land resource surveys to determine the relative proportion of mineral particles (sand, silt, clay) and the potential for long-distance transport. The classification of surface soil textures into three categories is summarised in Table 6, and surface soil texture in the Wet Tropics is mapped in Figure 10.

A complete list of soil texture codes considered in this assessment and their classification into four categories (sand, loam, clay and other) is provided in Appendix D.

Table 6. Categories for soil transport potential and corresponding surface soil textures.

Category	Surface soil texture
Sands	Sand (general equivalent field texture: sand, loamy sands, clayey sands).
Loams	Loam (general equivalent field texture: sandy loams, loam, clay loams, silty loams).
Clays	Clay (general equivalent field texture: light clays, medium clays, heavy clays)
Other	Peat or non-mineral soil

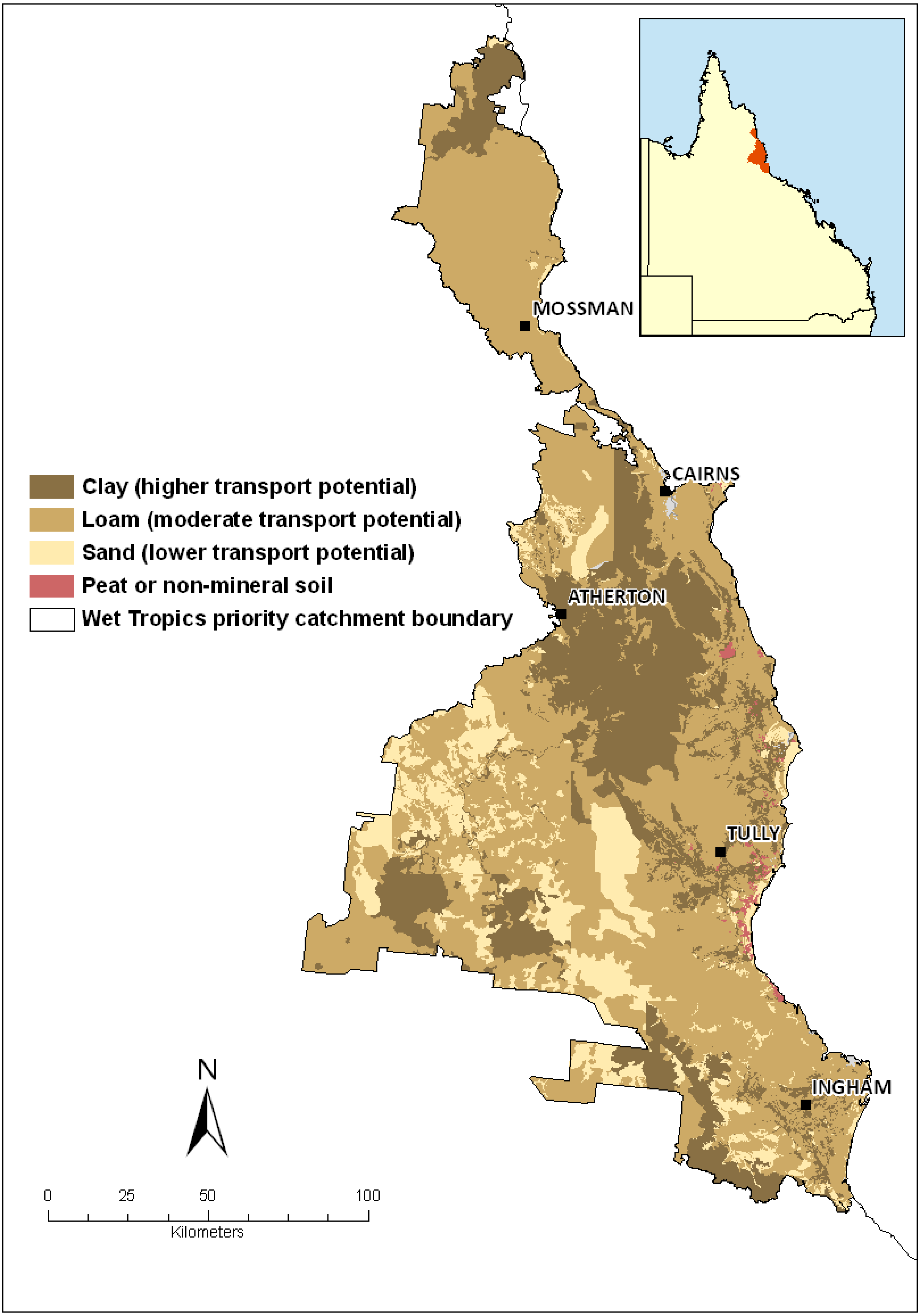


Figure 10. Soil transport potential for the Wet Tropics priority catchment.

Future work

This report outlines the process used to develop environmental characteristic maps for use in sugarcane growing areas of the Wet Tropics priority catchment. The following recommendations for future work within the reef protection package were received during stakeholder reviews:

- Investigate how to progress longer-term projects proposed at review workshops, such as:
    - identifying areas susceptible to groundwater transport
    - documenting soil chemistry interactions
    - obtaining spatial information regarding man-made drain networks.
- Consider which aspects of this report, maps and user guide would be better communicated via extension activities.

It is anticipated that over time, future versions of this report and supporting environmental characteristic maps could be used with information about management practices to identify areas that present a higher risk to the Great Barrier Reef (Figure 11). This would assist in the following processes:

- identification of research and information gaps, which can be input into monitoring programs and shared through extension programs
- assist landholders, extension officers and Reef Protection Officers to understand how landscape characteristics interact with management systems at a property or regional scale.

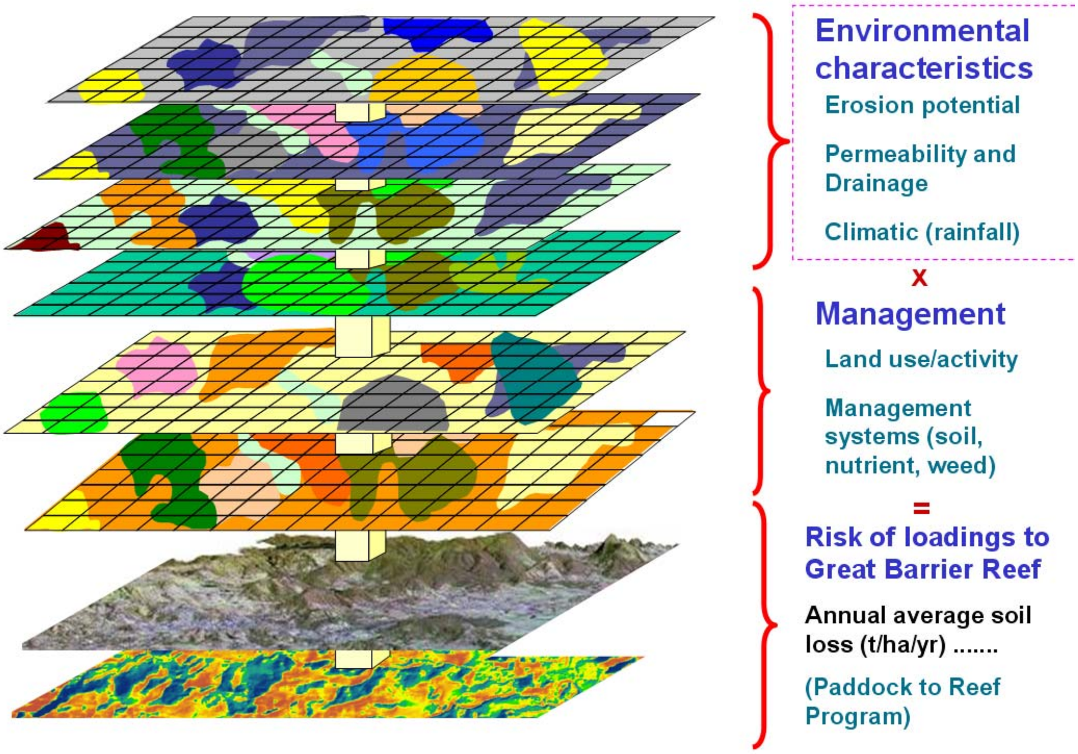


Figure 10. In the future, high-risk areas may be identified by layering environmental characteristics with land management systems.

References

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Appendix A Project stage 1 – identified environmental characteristics and data sets

Stage 1 of the project identified the environmental characteristics that are inherently linked to GBR water quality, all the data sources that were identified as potentially useful to represent environmental characteristics, and the rationale for the inclusion or exclusion of the data is also detailed.

Environmental characteristic	Data	Comments on data utility	Data limitations	Scale limitations	Data used in assessment
Erodible landscapes (erosion potential)	Erosion limitation data from DERM Versatile Cropping Lands project	These data indicate erodible soils in cropping lands based on parent material and slope. Erosion limitation values assigned to individual polygons during land resource assessment.	Extent limited to cropping lands.	Land resource data varies in scale from 1:25 000 – 1:100 000	Yes
	Universal Soil Loss Equation (USLE) method (only RKLS factors) R = Rainfall erosivity K = Soil erodibility L = Slope length S = Slope steepness	This method is used to estimate long-term annual hillslope erosion.	Does not translate well to non-cropping lands on steep slopes as it was developed from a limited range of slope and soil types (mostly within cropping lands.) USLE does not address gully or stream bank erosion.	Grid generated from inputs of various scale. Planned improvements using finer-scale inputs.	No – erosion limitation data considered more appropriate for this project due to derivation method (see above).
	Water Quality Improvement Plans (WQIP) (Barron & Haynes 2009, Kroon 2008)	This data may provide estimates of sediment contributions from hillslope, bank and gully erosion for sub-catchment in Reef catchments.	WQIPs are not available for all sub-catchments in the Wet Tropics.	Indicative at a coarse scale for Wet Tropics WQIP.	No – finer-scale information is required for this project.
	Reef regional assessment (Brodie *et al.* 2009)	Data provides estimates of sediment contributions from hillslope, bank and gully erosion for sub-basins in Reef catchments.	Indicative at sub-basin scale. Variable data availability limits confidence in some sub-basins of the Wet Tropics.	Indicative at sub-basin scale. Variable data availability limits confidence in some sub-basins of the Wet Tropics.	No – finer-scale information is required for this project.

Environmental characteristic	Data	Comments on data utility	Data limitations	Scale limitations	Data used in assessment
	Ground Cover Index	Data represent an annual assessment of vegetative ground cover.	Within the context of this project, ground cover is the result of natural landscape characteristics as well as management. Incorporates rocky areas as bare ground even though these areas are not subject to erosion.		No—not appropriate within the context of this project due to ground cover influenced by land management.
Flooded landscapes (flooding frequency)	Flooding limitation data from DERM Versatile Cropping Lands project	These data indicate flood-prone areas and the frequency of flooding in cropping lands. Flooding is an important mechanism for contaminant transport to the GBR.	Extent limited to cropping lands.	Land resource data varies in scale from 1:25 000 – 1:100 000	Yes
	Regional ecosystem and vegetation mapping (Neldner *et al.* 2005)	Landzone attributes in these data map the extent of alluvial environments. Flooding is an important mechanism for contaminant transport to the GBR.	Includes non-active alluvial environments. Does not predict the frequency or duration of flood events.	1:100 000 available state-wide	No—includes non-active alluvial environments.
Distance to stream	1:100 000 drainage	Useful analysis for distance of contaminant transport pathway from farm to watercourse.	Drainage density between map sheets is inconsistent. The application of these data is limited by the lack of knowledge about stream-sediment delivery processes.	1:100 000 available state-wide	No—insufficient knowledge of stream delivery processes.
Runoff generating landscapes (runoff potential)	Dominant water pathway	A set of rules that predicts the predominant water pathway for nutrient transportation for example via runoff/ponding or deep drainage/lateral flow		Land resource data varies in scale from 1:25 000 to 1:2 000 000	Yes.

Environmental characteristic	Data	Comments on data utility	Data limitations	Scale limitations	Data used in assessment
Soil transport potential	Soil surface texture	Indicates potential of soil to bind to nutrients and pesticides and be entrained	Transport process is specific to the type of nutrients and pesticides applied.	Land resource data varies in scale from 1:25 000 to 1:2 000 000	Yes

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Appendix B List of land resource publications relevant to Wet Tropics

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Appendix C Water pathway decision matrix

Soil drainage and permeability characteristics describe how water moves through the soil and are determined during soil sampling by field officers. Drainage and permeability classes were combined to produce a water pathway matrix as detailed in Moody and Cong (2008). The drainage and permeability characteristics for each class are outlined below.

Permeability class [A]	Drainage class[A]					
	1	2	3	4	5	6
1	R/P	R/P	R/P	R/P	R/P	D + R/P
2	R/P	R/P	R/P	D + R/P	D + R/P	D + R/P
3	R/P	R/P	R/P	D + R/P	D	D
4	R/P	R/P	D + R/P	D + R/P	D	D

D= drainage/lateral flow; R/P = runoff or ponding, depending on slope

Drainage and permeability characteristics

Drainage refers to the rate of removal of water from the soil profile and is a statement about soil and site drainage that is likely to occur in most years. It is affected by both internal and external attributes that may act together and/or separately (McDonald *et al.* 1990).

Drainage class	Description
1 Very poorly drained	Water is removed from the soil so slowly that the water remains at or near the surface for most of the year.
2 Poorly drained	Water is removed very slowly from the soil in relation to supply which may result in seasonal ponding. A perched water table may also be present.
3 Imperfectly drained	Water is removed slowly from the soil. Intermittent waterlogging throughout the soil results in many profiles having gleyed, mottled colours or rusty root channel linings.
4 Moderately well drained	Water is removed relatively slowly after supply. Some horizons may remain wet for as long as one week after water addition.
5 Well drained	Water is removed readily but not rapidly from the soil. Some horizons may remain wet for several days after water addition.
6 Rapidly drained	Water is removed from the soil rapidly. The soil is not normally wet for more than several hours after water addition.

Permeability refers to the potential of a soil to transmit water internally and this attribute is assessed for the least permeable horizon in the soil profile. It is independent of the soils' position in the landscape and climate (McDonald *et al.* 1990).

Permeability class	Description
1 Very slowly permeable	Transmission through the least permeable horizon is very slow. It would take at least a month for the profile to reach field capacity after wetting.
2 Slowly permeable	Transmission through the least permeable horizon is slow. It would take at least a week or more after wetting for the soil to reach field capacity.
3 Moderately permeable	Transmission through the least permeable horizon is relatively fast, field capacity Is reached between 1–5 days after wetting.
4 Highly permeable	Transmission through the least permeable horizon is very fast, field capacity is reached within 1–12 hours after wetting.

[A]McDonald RC, Isbell RF, Speight JG, Walker J & Hopkins MS (1990) *Australian Soil and Land Survey Field handbook*, 2nd edition, Inkata Press, Melbourne.

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Appendix D Surface soil texture categories

All soil texture codes have been generalised into four categories: sand, loam, clay and other. The category 'other' incorporates non-soils (e.g. gravel) and non-mineral soils (e.g. peats).

NOTE: This table does not include the alluvial soils in the Wet Tropical Coast area (with a light clay surface texture) which have been reclassified into the loam category for the purpose of this assessment.

Texture code	Texture description	Notes	Category
AP	sapric peat	non-mineral soil	other
CFS	clayey fine sand	clay content < 10%	sand
CKS	clayey coarse sand	clay content < 10%	sand
CL	clay loam	30–35% clay	loam
CLFS	clay loam, fine sandy	30–35% clay	loam
CLKS	clay loam, coarse sandy	30–35% clay	loam
CLS	clay loam, sandy	30–35% clay	loam
CS	clayey sand	clay content < 10%	sand
FS	fine sand	clay content < 10%	sand
FSC	fine sandy; clay	assume 35 % clay	clay
FSCL	fine sandy clay loam	20–30% clay	loam
FSHC	fine sandy heavy clay	> 40% clay	clay
FSL	fine sandy loam	10–20% clay	loam
FSLC	fine sandy light clay	35–40% clay	clay
FSLMC	fine sandy light medium clay	> 40% clay light medium clay	clay
FSMC	fine sandy medium clay	> 40% clay	clay
FSMHC	fine sandy medium heavy clay	> 40% clay	clay
HC	heavy clay	> 40% clay	clay
IP	fibric peat	non-mineral soil	other
KS	coarse sand	clay content < 10%	sand
KSCL	coarse sandy clay loam	20–30% clay	loam
KSL	coarse sandy loam	10–20% clay	loam
KSLC	coarse sandy light clay	35–40% clay	clay
KSLMC	coarse sandy light medium clay	> 40% clay	clay
KSMC	coarse sandy medium clay	> 40% clay	clay
KSMHC	coarse sandy medium heavy clay	> 40% clay	clay
L	loam	25% clay	loam
LC	light clay	35–40% clay	clay
LCKS	light clay; coarse sandy	35–40% clay	clay
LCZ	light clay; silty	35–40% clay	clay
LFS	loamy fine sand	25% clay	sand
LFSY	loam; fine sandy	25% clay	loam
LKS	loamy coarse sand	clay content < 10%	sand
LMC	light medium clay	> 40% clay light medium clay	clay
LMCFS	light medium clay; fine sandy	> 40% clay light medium clay	clay

Texture code	Texture description	Notes	Category
LS	loamy sand	clay content < 10%	sand
MC	medium clay	> 40% clay	clay
MCFS	medium clay; fine sandy	> 40% clay	clay
MHC	medium heavy clay	> 40% clay	clay
S	sand	clay content < 10%	sand
SC	sandy clay	assume 35 % clay	clay
SCL	sandy clay loam	20–30% clay	loam
SL	sandy loam	10–20% clay	loam
SLC	sandy light clay	35–40% clay	clay
SLMC	sandy light medium clay	> 40% clay light medium clay	clay
SMC	sandy medium clay	> 40% clay	clay
SMHC	sandy medium heavy clay	> 40% clay	clay
ZC	silty clay	assume 35 % clay	clay
ZCL	silty clay loam	30–35% clay	loam
ZL	silty loam	25% clay	loam
ZLC	silty light clay	35-40% clay	clay
ZLMC	silty light medium clay	> 40% clay light medium clay	clay
ZMC	silty medium clay	> 40% clay	clay
ZMHC	silty medium heavy clay	> 40% clay	clay