1 Background

The Alligator Rivers Region Technical Committee (ARRTC) identified as a key goal the need to continue developing knowledge management systems for effective communication and decision support for regional natural resource management and environmental assessments. Supporting this development, the Environmental Research Institute of the Supervising Scientist (***eriss***) has adopted an ecological risk assessment framework to underpin the organisation of environmental information.

In order to achieve this aim, and to assess ecological impacts from mining in the ARR in context with other potential stressors, the Independent Science Panel (ISP) of the International Council of Scientific Unions, and the World Conservation Union, acting on behalf of the World Heritage Committee, recommended that it was necessary to:

- first conduct an assessment and collation of existing information at a landscape-catchment scale in order to identify gaps in knowledge and to establish and prioritise research needs; and
- conduct a more comprehensive risk assessment of both freshwater and terrestrial ecosystems at a landscape scale, because the region is subject to change and variability due to influences not immediate to mining activity, such as other land use practises, climate, and the introduction of invasive species (Bellio et al 2004a).

In response to these recommendations, ***eriss*** initiated a program of landscape-wide projects aiming to link environmental threats and pressures (mining, invasive species, climate change, and salt-water intrusion) to selected ecosystems in the ARR, particularly freshwater wetlands. The ecological risk assessment program aims to identify the potential likelihood, extent and severity of mining impacts in the ARR and to separate effects of such impacts from those caused by other potential (non-mining) environmental stressors. In addition the program aims to place these potential impacts in context for land managers by quantifying the risks.

This report aims to document available spatial data useful for conducting ecological risk assessment of the Magela Creek floodplain. Essential to this exercise has been the identification and collation of spatial datasets indicative of environmental threats and assets in the ARR and the incorporation of these data into a standardised form for spatial risk modelling purposes. It is hoped that this document will assist in the development of an effective knowledge management system for stakeholders in the region through: 1) providing a compendium of currently available spatial information for the ARR, and specifically the Magela floodplain; and 2) outlining a framework to facilitate routine landscape-scale ecological risk assessment analyses;

To provide an objective risk assessment it is incumbent upon the analyst to effectively communicate uncertainties in information used for the assessment (Burgman 2005). Identification of gaps and uncertainties of data, and effective communication of this information to stakeholders, therefore, underpins any ongoing risk assessment exercise, and helps to direct further research and monitoring. Consequently data quality assessments were also conducted for each dataset in accordance with accepted international standards, including an assessment of gaps and uncertainties in available information.

In summary, this spatial data compendium is provided for the exercise of ecological risk assessment in the ARR. Abstract reports of the data layers are arranged under three headings: 1) Environmental assets (including data on waterbirds and native wetland vegetation in the ARR); 2) Environmental threats (including data layers for feral animals, and weeds); and

3) Environmental character (physical drivers independent of assets and threats that nevertheless can interact with them or influence ecosystem processes such as fire history, hydrology and infrastructure). Complete metadata reports are contained within the appendices.

While the aim has been to provide summaries of all spatial data relevant to the ARR, their inclusion in this report does not necessarily mean that they will be applied in the final risk assessment process. As has already been stated, the primary aim was to summarise 'existing information at a landscape-catchment scale in order to identify gaps in knowledge and to establish and prioritise research needs'. Therefore the applicability of specific data layers to the formulation of an ecological risk assessment model will need to be reviewed after initial model development.

This GIS compendium provides an information resource to land managers in the region, summarising spatial data currently available to assess potential ecological risks to the natural environment of the ARR, and in particular the Magela Creek floodplain. While considered relatively complete with respect to data available at the time of publication, a number of information gaps are also apparent. It is hoped that this document will promote debate towards the development of a more comprehensive spatial database for ecological risk assessment and land management planning in the ARR.

1.1 Measurement endpoints used for risk assessment

This section outlines the spatial information sources used for the non-mining component of the landscape-scale ecological risk assessment project as they relate to available measurement endpoints (MEs) for the assessment. In order to describe MEs in context it is first useful to outline the process of ecological risk assessment.

Essentially ecological risk assessment is a framework and decision support tool for assessing and managing multiple ecological risks at multiple scales. The term is ascribed to the method(s) for determining risk posed by a stressor (contaminant or perceived threat) to the survival and health of ecosystems (natural assets). The general steps for performing ecological risk assessment, as applied to an identified 'stressor', are outlined in Figure 1. Under these procedures ***risk*** is defined as the probability that an adverse effect will occur as a result of ecosystem exposure to a particular concentration of the stressor. Hence ***risk*** is determined by measuring two components:

1 the ***consequences*** (also measured as effects/extent) of an adverse event, and

2 the ***likelihood*** or *probability* of the event occurring (exposure).

Using these criteria, risk is calculated as the probability of an adverse event, or the likelihood of exposure multiplied by the consequences or effects of that exposure ($P_{risk} = P_{exposure} \times P_{effects}$). In turn, risk level can be measured for each identified 'stressor', separately, and then comparisons of the relative risk contribution from multiple stressors can be made.

A general outline for the ecological risk assessment of the Magela Creek floodplain is shown in Figure 2 (Bayliss, van Dam & Humphrey 2006). Broad assessment endpoints chosen to evaluate risks (from mining and non-mining stressors) are:

- the conservation of the biological diversity of the ARR based on World Heritage Values of KNP for which the Australian government is under international obligation to protect, and
- the protection of the health of people of the ARR.

Measurement of the risks to these values from diffuse landscape threats relate to exposure of specific threats (eg spatial extent of weeds or feral animals) to key natural assets (such as significant habitat for magpie goose). The distribution and extent of threats measured in relation to the displacement of natural habitat form the measurement endpoints in the assessment. Implicit is the need for benchmarking of natural assets (eg definable habitats), where relatively homogeneous vegetation communities (or habitats) form the basic landscape unit for assessment and management planning.

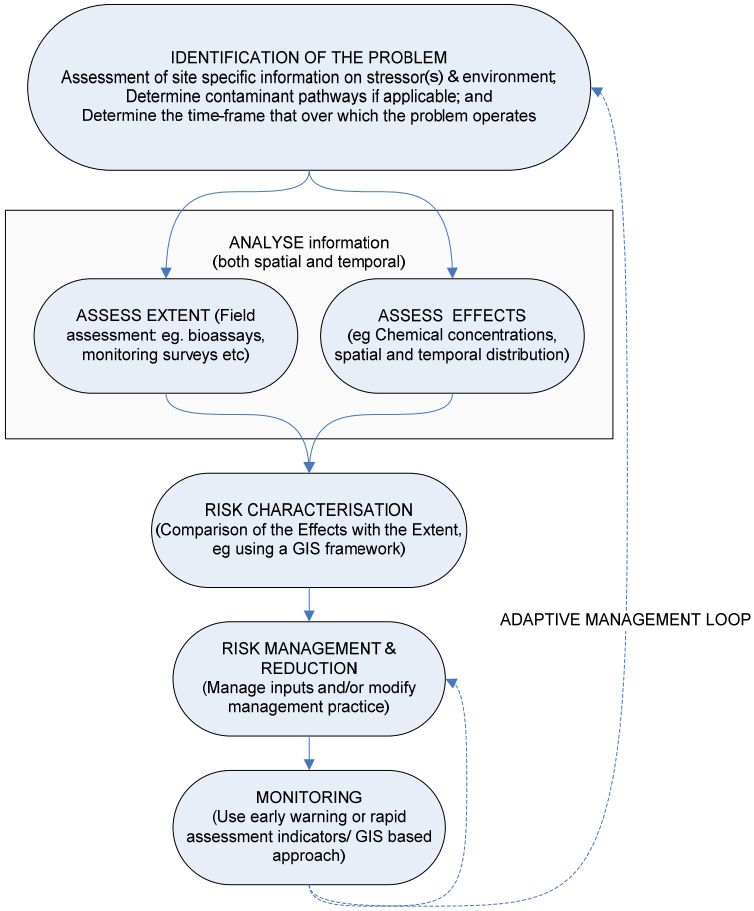

Figure 1 A basic framework for conducting Ecological Risk Assessment (adapted from US EPA 1998)

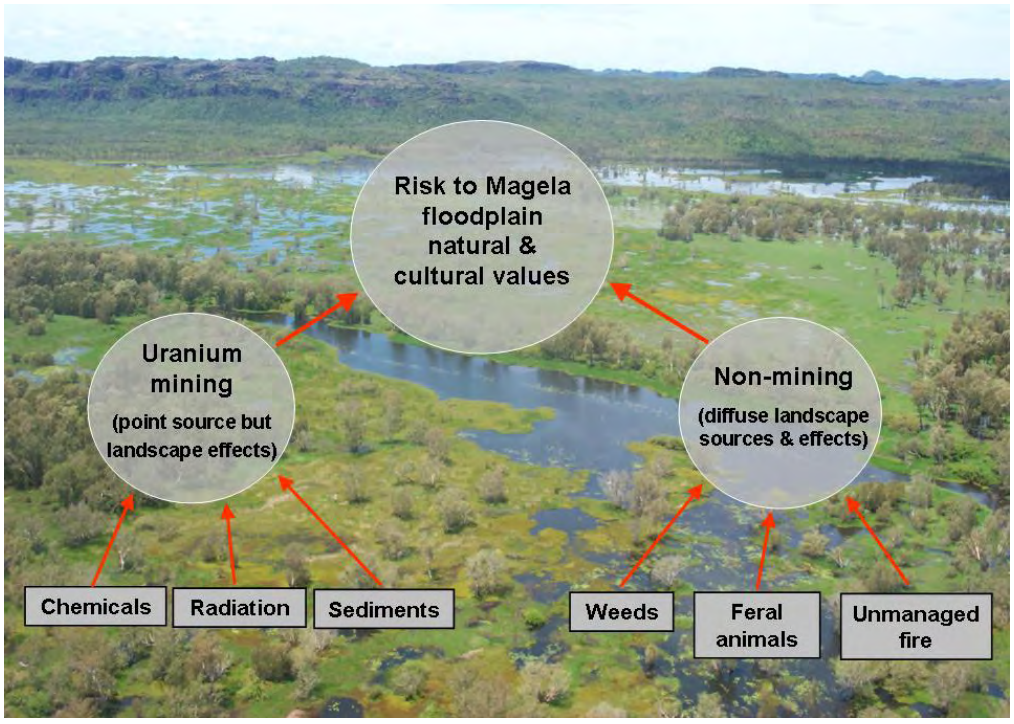

Figure 2 Ecological stressors considered in the relative risk model for the Magela floodplain (source: Bayliss et al 2006a)

Hence, aspects of the datasets reported here that need be understood in relation to the ecological risk assessment of the Magela floodplain are:

- a recognition of the measurement endpoints indicative of ecological change over different scales (as they relate to measuring both the status of World Heritage Values of wetlands and the health of the local community in the ARR);
- the limitations, assumptions and context-dependence of *measurement* endpoints, as they relate to *assessment* endpoints; and on this basis
- issues of data interpretation, accuracy and reliability of information being used to derive endpoints.

These factors are also relevant to planning future monitoring programs, and for improving rigour and precision of risk assessments. Measurement endpoints used in the ecological risk assessment, and potential quality control and assurance issues are summarised in Table 1. Available data are identified for each measurement endpoint.

More thorough description of endpoints as they relate to the assessment of wetland assets, and the potential threats to them are found in sections 2 and 3 (assets and threats), respectively. Section 4 outlines datasets used to define the physical attributes of the Magela floodplain and surrounding landscape, including topography, fire regime, and infrastructure (tracks and roads). The latter two are intrinsically related to land management and the history of human occupation. These attributes may also be considered as 'threats' under some circumstances. For example, where fire is a natural part of the environment in Kakadu, an 'unmanaged' fire regime can contribute to reduction in local biophysical heterogeneity of the landscape, thus impacting on biodiversity.

1.2 Spatial data reporting

Spatial data associated with the Magela floodplain risk assessment project have been incorporated into a GIS maintained at ***eriss***. In general, all datasets are publicly available by application through the data custodian, on condition that original ownership and data lineage are appropriately acknowledged. A summary of all datasets is provided in Table 2.

For each data layer a brief abstract is provided in sections 2 to 4 (cross-referenced to a complete metadata report in the Appendices). Metadata descriptions follow the Spatial Information Council of Australia and New Zealand (SICANZ) reporting standard for spatial metadata (ANZLIC 2001). The SICANZ metadata thesauri were used to derive keyword and qualifier search terms for each report and the ISO metadata topic category thesauri were also used for selection of broader classification terms.

Spatial data have been projected to the Australian standard, Geodectic Datum of Australia 1994 (GDA94), and using the appropriate map zone (Map Grid of Australia 1994) such that analyses can be conducted using the metric scale. When the dataset extent encompassed more than one map grid zone the dataset is projected using the geographic coordinate system. With respect to the ecological risk assessment of the Magela floodplain, spatial data subsets delineating this region (Figure 3) were derived from each original data layer and projected to GDA94, MGA zone 53. Wetland areas depicted on maps are derived from AUSLIG 1:250000 map series where they are classed as 'swamps and land subject to seasonal inundation'.

Table 1 Datasets used to characterise risk to World Heritage Values of Magela floodplain, the measurement endpoints used, and potential limitations of data sources

Measurement endpoint		Indicator	Links/interactions	Potential confounding influences for Magela floodplain assessment
Assets	Distribution and abundance of waterbirds (aerial surveys data)	• indicative of 'health' of waterbird populations for iconic species	• Waterbirds are partly dependent on high-energy native vegetation resources (eg *Oryza* spp & *Eleocharis dulcis*)	• Population home-range extends over local and regional scales
	Distribution and spatial extent of native macrophyte habitats (from various floodplain mapping studies)	• Indicative of the 'health' of native vegetation habitats critical for waterbird conservation • Potential indicator of the quality of environment for Indigenous land use (hunting and gathering)	• Relates to the quality of habitat for waterbirds (magpie geese & egrets) • Can be used to monitor success of invasive species control programs at a habitat-specific scale • Potential indicator of climate change and/or salt-water intrusion into freshwater wetlands • Fire regime can influence successional state of vegetation on floodplains (eg Boyden et al 2003)	• Although they relate specifically to the Magela floodplain, multi-temporal datasets are not standardised: Different sampling methodology and scales are used between datasets.
Threats	Distribution and abundance of feral animals and estimates of habitat damage (aerial surveys)	• Semi-quantitative indicator of the spatial extent and relative 'severity' of visible damage by feral pigs in floodplain and terrestrial habitats • Indicates relative abundance of species counted	• Relates to the exposure of natural assets on floodplains to feral animal activity and hence the potential for change/displacement of these resources • May be used to monitor success of feral animal control programs	• Relative abundance estimates potentially unreliable for some species (pigs) • Visual estimates of 'damage' while indicative of presence of pigs, may not directly relate to measurable ecological impact;
	Weed mapping (various sources)	• Distribution and density of para grass & other weeds derived from field surveys and remote sensing	• Relates to the exposure and displacement of native vegetative habitats to weeds (esp para grass) • Can be used to monitor success of weed control programs • Possible interactions with fire regime (by increased fuel loads & fire intensity) • Possible reduction of nutrients to aquatic food webs (Bunn et al 1997) • Possible changes in floodplain channel morphology and hydrodynamics (Bunn et al 1998)	• Techniques for monitoring para grass using remote sensing are under development; • and comprehensive accuracy assessment has not been undertaken. Preliminary map classifications have been used.
	Seasonal (early vs. late dry season) fire scar history from BFC (derived from remote sensing)	• Fire regime. While fire is a natural part of the landscape, 'unmanaged' fire may be considered a potential threat to conservation of habitat diversity. • Late dry season fires contribute more CO_2 emissions than early season fires (ratio of EDS:LDS may be a useful indicator, weighted by total extent)	• Fire regime (frequency & timing of burns) can alter availability of specific wetland vegetation resources ; • A 'low' frequency burning regime has been implicated in reduction of both floodplain habitat diversity and the quality of wetlands for indigenous landuse (Boyden et al 2003, Christophersen et al 2003). • Fire can influence runoff input of nutrients and sediments into aquatic systems (Townsend, Douglas & Setterfield 2004). This may influence the magnitude of seasonal plant production pulses on floodplains • CO_2 emissions contribute to global warming	• While accuracy of fire-scar mapping is considered high for terrestrial environments (>80%), accuracy assessments data for floodplain environments are limited.

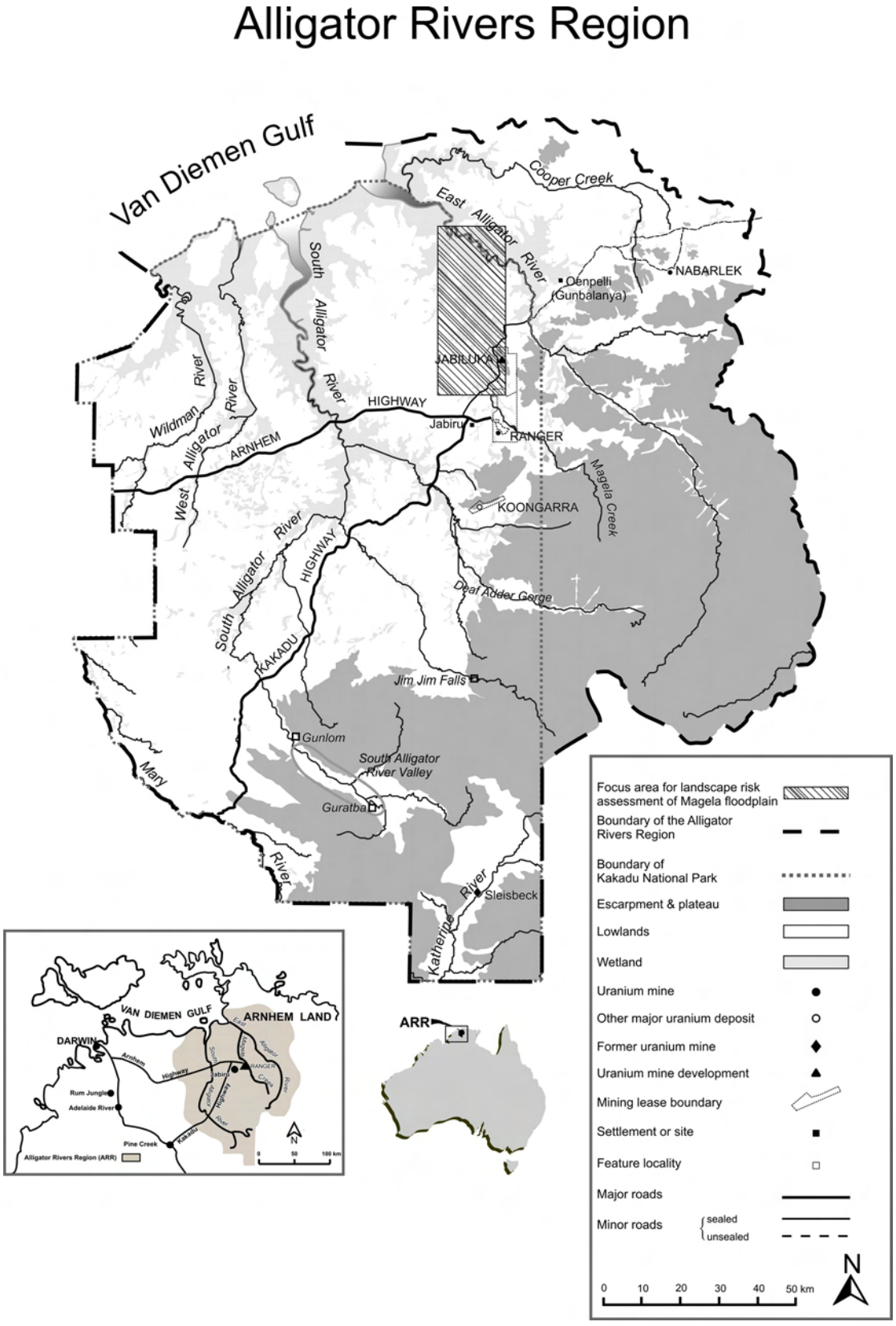

Figure 3 The Alligator Rivers Region in Australia's Northern Territory showing the area for landscape scale risk assessment of the Magela floodplain (hatched area). The boundary of Kakadu National Park, within the Region, is indicated.

Table 2 Summary of spatial data layers available for the ARR with potential use in ecological risk assessment grouped by assets, threats, environmental character and management zones

Category	Layer Description	Custodian	Source(s)	Format(s)	General coverage of datasets within Kakadu NP (see tables for coordinates)
Assets	Waterbirds	PWCNT	Aerial surveys of waterbirds in 2001 & 2003	Point shapefile data and derived raster grids	Complete coverage of major wetlands within Kakadu NP
	Native Vegetation Communities	DEWHA	Schodde et al 1987 & Storey et al 1969 &1976	Vector polygon shapefile and derived raster grids	Complete coverage of Kakadu NP
		DEWHA	Boyden et al 2003	Raster grids & derived vector polygon shapefiles	Covers Boggy Plains, Sth Alligator River only
		DEWHA	Finlayson et al 1989	Vector polygon shapefile and derived raster grids	Complete coverage of Magela floodplain
		DEWHA	Lowry et al 2005	Vector polygon shapefile and derived raster grids	Complete coverage of Magela floodplain
	Land units	PWCNT	Wells 1979	Vector polygon shapefiles	Complete coverage of Magela catchment
Threats	Feral Animals	PWCNT/ ***eriss***	Aerial surveys of feral animals in 2001 & 2003	Point shapefile data and derived raster grids	Complete coverage of lowland landscapes, including wetlands within Kakadu NP
	Weeds	***eriss***	Satellite remote sensing	Point shapefile data for field surveys and 2.7m pixel image data	Partial coverage of Magela floodplain
		PAN	PAN central weeds database	Point shapefile data	Point data from opportunistic field surveys within Kakadu National Park
		eriss	*eriss* field surveys	Point shapefile data and derived raster grids	Point data from opportunistic field surveys within Magela floodplain
		DPIFM	NT government data	Point shapefile data	Point data from opportunistic field surveys within Kakadu National Park
		PAN	Cowie & Werner 1987/88	Point shapefile data	Point data from opportunistic field surveys within Kakadu National Park
		eriss	Knerr 1998	Point shapefile data	Point data from opportunistic field surveys within Kakadu National Park

PAN = Parks Australia North, DEWHA = Department of the Environment, Water, Heritage and the Arts; DIGO = Defence Imagery & Geospatial Organisation; BFC = Bushfires Council of the NT; ARR= Alligator Rivers Region

Table 2 (continued)

Category	Layer Description	Custodian	Source(s)	Format(s)	General coverage of datasets within Kakadu NP (see tables for coordinates)
Environmental characteristics	Infrastructure	***eriss*** & Geoscience Australia	1:50 000 DIGO Geoscience Australia & QuickBird™)	Vector polygon shapefiles and derived raster grids 1:250k Geodata & 1:50k DIGO*	Entire ARR region, including KNP (1:50 000 data) including updated information from QuickBird™ data (for partial coverage of the Magela Ck. Catchment)
	Distance to water	Geoscience Australia	1:250 000 Geoscience Australia	Interpolated raster grids from vector polygon shapefiles	General coverage of datasets within KNP (see tables for coordinates)
	Wetland areas	Geoscience Australia	1:250 000 Geoscience Australia	Vector polygon shapefiles and derived raster grids	Complete coverage of KNP
	Fire scar history	BFC	BFC Landsat	Vector polygon shapefiles	Complete coverage of KNP
	Digital elevation model for the Magela floodplain (uses available high-resolution data with gaps substituted by low-resolution data)	DEWHA	Combination of data from DIGO (low-resolution) & NRETA (high-resolution)	Raster	Complete KNP region (low-resolution data) and including partial high-resolution coverage of Magela floodplain by data component.
Management zones	Feral animal management zones	PAN/***eriss***	Boundaries digitised from PAN NRM hardcopy maps by ***eriss***	Vector polygon shapefiles	For selected management districts of KNP
	KNP Boundary	PAN/DEWHA	DEWHA	Vector polygon shapefiles	Delineates the KNP region
	Mining Leases of the ARR	DEWHA	DEWHA	Vector polygon shapefiles	Delineates mineral leases within KNP

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