# WETLAND MAPPING AND CLASSIFICATION:

# AREA D, SHIRE OF WEST ARTHUR

Prepared for:

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### Department of Environment and Conservation

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## 1 INTRODUCTION

ENV Australia Pty Ltd (ENV) was commissioned by the Department of Environment and Conservation (DEC) to undertake mapping and classification of wetlands for a project area referred to as "Area D". Area D is approximately 150,000ha and located within the Wheatbelt region of Western Australia in the vicinity of Duranillin in the Shire of West Arthur.

For the purpose of this study the definition of a wetland is consistent with that presented in the *Wetlands Conservation Policy for Western Australia* and is adopted from the Ramsar Bureau (UNESCO, 1971).

"Areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salt, including areas of marine water the depth of which at low tide does not exceed six metres." (UNESCO, 1971)

Western Australia has significant wetland resources providing a broad range of ecological, hydrological and economic values. The State's wetlands are subject to ongoing degradation and loss through direct and indirect impacts of clearing and development including groundwater extraction, and large-scale processes such as salinisation and climate change.

Mapping, classification and evaluation of wetland resources is required to document locations, extents and values of wetlands and to provide a systematic and robust basis for protection and management. Improved knowledge is also required to provide meaningful input to environmental impact assessment and related decision making processes.

#### 1.1 BACKGROUND

The DEC is responsible for coordinating the mapping, classification and evaluation of wetlands around the State. It coordinates the Wetland Status Working Group, a subcommittee of the (State) Wetlands Coordinating Committee, to address wetland mapping, classification, and evaluation and status matters in accordance with the Wetlands Conservation Policy for Western Australia (Government of Western Australia, 1997). In this respect, the DEC has prepared a document entitled *Framework for mapping, classification and evaluation of wetlands in Western Australia* (DEC, in publication), in cooperation with the Wetland Status Working Group, which has been endorsed by the Wetlands Coordinating Committee.

Wetland mapping in Western Australia has been an ongoing project. In 1996 the publication of the *Wetlands of the Swan Coastal Plain* (Hill. et al, 1996) comprised the first mapping effort that considered water permanence, soil and vegetation in wetland mapping. The approach of this original project was highly



focused on the use of field work and hard copy stereoscopic aerial photographs to delineate wetland boundaries. Since then, methods for mapping wetlands in Australia have evolved to include the use of geographic information systems and digital spatial datasets to help streamline the mapping process (Queensland Government, 2007).

#### 1.2 AIMS AND OBJECTIVES

The two overarching aims of this study are to:

- Gather sufficient information on the mapped boundaries of wetland areas to contribute to the knowledge of their values, functions and attributes within Area D to provide this basis for protection, management and decision making purposes.
- 2. Develop a mapping methodology that utilises computer based geographic information systems to delineate and classify wetlands.

Further objectives of this study are to:

- Compile a spatial dataset of relevant mapped phenomena.
- Conduct a field survey of approximately 10% of mapped wetlands to assess the methodology of mapped wetland boundaries and classification.
- Identify wetland boundaries in the field through assessing landform, hydrology, soils and vegetation.
- Assess and refine mapped wetland boundaries based on observations and data collected in the field.
- Provide a measure of accuracy for the desktop mapping based on field observations.
- Compile a dataset of mapped wetland boundaries and their classification throughout Area D.

#### 1.3 SCOPE OF WORKS

ENV has undertaken this study to be consistent with the requirements for a Stage 2 Assessment according to the *Framework* for *mapping, classification, and evaluation of wetlands in Western Australia* (DEC, in publication).

The DEC defines a Stage 2 assessment as "including identification of preliminary wetland boundaries, classification of wetlands into geomorphic types and identification of groups of wetlands (consanguineous suites)" (DEC, in



publication). The purpose of a Stage 2 assessment is to provide precise or approximate boundaries and has a requirement for field sampling of a sub-set and extrapolation of information (DEC, in publication).

In the tender document the DEC identified that consanguineous suites and artificial wetlands are **not** required as part of this study.

ENV has adopted the following scope of works to map and classify wetlands in Area D:

- Identify, collate and review reference documents and digital datasets collected from State agencies.
- Map and identify wetland boundaries to a scale of 1:25,000 using remotely sensed data and geographic information systems.
- Provide a geomorphic classification for each mapped wetland (types listed in Table 1 Section 3.2).
- Conduct a field survey to clarify and assess the accuracy of the provisionally mapped wetlands across Area D
- Provide a final report detailing the information and methodology that were applied to determine wetland boundaries and types, and
- Deliver final mapping deliverable to be supplied as an ESRI shapefile in polygon format.



# 2 PHYSICAL ENVIRONMENT

#### 2.1 LOCATION

Area D is approximately 150,000ha and located within the Wheatbelt region of Western Australia (Figure 1). Area D is in the vicinity of Duranillin in the Shire of West Arthur. The area is encompassed by the following 1:25,000 map sheets for the Middle Blackwood:

- 2231-III NE;
- 2231-III SE;
- 2230-IV NE;
- 2231-II NW;
- 2231-II SW;
- 2230-I NW;
- 2231-II NE;
- 2231-II NE; and
- 2230-I NE.

#### 2.2 EXISTING LAND USE

Area D is predominantly cleared land with the majority of the area being used for stock grazing and agriculture. The area is regarded as a high yielding area for sheep wool production but other stock is found including cattle and horses (Shire of West Arthur, 2004).

The townsites of Darkan, Hillman, Cordering, Duranillin, Moodiarrup, and Boolading are located within Area D (Figure 1).

#### 2.3 CLIMATE

Area D is characterised by a Mediterranean climate with cool wet winters and dry hot summers. Rainfall is greater from mid-May to the end of August (Figure 3). Long-term average annual rainfall in the area from 1885-2008 is 519mm according to Bureau of Meteorology (BOM) recordings from the nearby Kojonup Station, station number 10582 (BOM, 2009).



#### 2.4 TOPOGRAPHY

The topography for Area D is undulating hills and river valleys associated with the Arthur River, Beaufort River and Hillman River. Area D is within the upper reaches of the Blackwood River catchment and generally falls from the north of the project area towards the Southern Ocean.

Topography generally varies between 200 and 390 mAHD across Area D. See Section 2.5 below for a description of the relationship of topography to geology.

#### 2.5 GEOLOGY AND SOILS

Area D is comprised of a number of geological subsystems as presented in Figure 4. Generally, Area D is composed of sandy soils in gravel with varying salinity and is underlain by granite. A description of the general properties of each geological subsystem taken from the Department of Agriculture and Foods' (2003) soil mapping is described below.

**Beaufort Subsystem**: Broad valley floors consisting of grey and brown, deep and shallow duplex sandy soils, generally saline in character and underlain by granite.

**Boscabel Subsystem**: Gently undulating rises and narrow valley floors consisting of yellow, brown and grey pale deep sands with sandy gravels, generally saline in character formed from alluvial and aeolian deposits and underlain by granite.

**Dalmore Subsystem**: Undulating ridges and hill crests consisting of deeply weathered gravels, pale sands, brown deep loamy duplex and grey deep sandy duplex soils underlain by granite.

**Darkan Subsystem**: Undulating rises and rolling low hills consisting of mostly duplex sandy gravels, deep sandy gravels, shallow gravels and grey deep sandy duplexes formed from laterite and colluvium underlain by granitic rocks.

**Dellyanine Subsystem**: Undulating rises and low hills on granite consisting of grey and brown sandy duplex (shallow and deep), sandy gravel underlain by granite intruded by dolerite and diorite dykes.

**Dwellingup Subsystem**: Divides lower to upper slopes and hillcrests consisting of sandy gravels and loamy gravels with minor areas of shallow gravels, deep sandy gravels, yellow and pale deep sands (often gravelly) underlain by granitic rocks.



**Farrar Substystem**: Undulating rises and low hills consisting of grey deep sandy duplex, sandy gravel, bare rock and red shallow loamy duplex formed from colluvium and deeply weathered mantle over granitic rocks.

**Harris Subsystem**: Broad poorly drained alluvial flats on the surface of the Darling Plateau consisting of saline wet soils with grey deep sandy duplex soils, formed from alluvium.

**Kulikup Subsystem**- Within Area D the ironstone gravel flats phase is present which is moderately well drained to poorly drained gravels formed from laterised sedimentary deposits over weathered mantle over gneiss and granite. Soils present are predominantly duplex sandy gravels, semi-wet soils and loamy gravels.

**Lukin Subsystem**: Shallow minor valleys with swampy floors incised into lateritic terrain consisting of sandy and loamy gravels, loamy duplex soils and deep sands from lateritic colluvium origin underlain by granite and gneiss.

**Mornington Hill Subsystem**: Low hills on laterite overlying granite consisting of sandy and loamy gravels with some deep sands and loamy earths formed from deeply weathered mantle and underlain by granitic rocks.

**Pindalup Subsystem**: Shallow minor valleys with gentle side slopes and broad swampy floors consisting of loamy gravels, deep sands and non-saline wet soils formed from alluvium and lateritic colluvium over weathered granitic rocks.

**Qualeup Subsystem**: Broad poorly drained flats between low hills, circular lakes and swampy depressions are common consisting of sandy gravels, deep sands and non-saline wet soils formed from laterised sedimentary deposits over weathered mantle, gneiss and granite.

**Sandalwood Subsystem**: Low hills rising above the general landscape consisting of loam and sandy gravels underlain by granitic rocks.

#### 2.6 REGIONAL VEGETATION

Area D is the Darling Botanical District within the Southwest Province. Within the Darling Botanical District, four subdistricts exist. Area D is located within the Menzies and Dale Botanical Subdistricts of the Southern and Northern Jarrah Forest Subregions.

The region is characterised by Jarrah forest in its northern and southern extents and is distinguished more by the nature of the understorey than by variation in the forest itself. In the southern region the understorey more resembles that occurring in the Karri region, in the northern it possesses a more strongly sclerophyll character (Gibson *et al.* 1994).



Remnant vegetation in the project area consists of mosaic plant communities but largely consists of woodlands of *Eucalyptus marginata* (Jarrah), *Corymbia calophylla* (Marri) and *Eucalyptus wandoo* (Wandoo) (Department of Agriculture and Food, 2003).



# 3 LITERATURE REVIEW

#### 3.1 GEOMORPHIC CLASSIFICATIONS OF WETLANDS

The geomorphic classification of wetlands is based landform and wetness attributes of a wetland.

The classification is based on the two key features present in all wetlands in Western Australia; presence of water and type of landform (Semeniuk & Semeniuk, 1995).

The four types of water permanence (or "wetness") that determine the occurrence of wetlands are:

- permanent inundation;
- seasonal inundation;
- seasonal waterlogging; and
- intermittent inundation.

The five landform types that are typically host to wetland types are listed below and depicted in Figure 4:

- basins;
- flats;
- channels;
- slopes; and
- highlands.

The categorisation of the water permanence associated with each wetland landform provides the basis for classification and is presented in Table 1 below:



	Landform					
Water Permanence	Basin	Flat	Slope	Channel	Highland	
Permanent Inundation	Lake	-	-	River	-	
Seasonal Inundation	Sumpland	Floodplain	-	Creek	-	
Intermittent Inundation	Playa	Barlkarra	-	Wadi	-	
Seasonal Waterlogging	Dampland	Palusplain	Paluslope	Trough	Palusmont	

Table 1: Wetland types according to the geomorphic classification system

(Semeniuk & Semeniuk, 1995)

#### 3.2 WETLANDS OF THE SWAN COASTAL PLAIN

In 1996, *Wetlands of the Swan Coastal Plain* was published in seven volumes based on the efforts of the (then) Water Authority of Western Australia, Department of Environment Protection, and private consultants. The document as a whole provided a comprehensive approach to planning, management and understanding of water resources across the Swan Coastal Plain.

Volume 2a of the series, *Wetland Mapping, Classification and Evaluation – Main Report* provides information regarding the extent of wetland studies done on the Swan Coastal Plain. This study considered wetlands and their characteristics as being influenced by a number of factors including soil types, vegetation, and landforms whereas previous efforts for wetland mapping focused on wetlands being identified through topographic mapping.

The methodology for wetland mapping is generally described in the document as a process involving the use of hard copy 1:25,000 stereoscopic aerial orthophotographs (herein referred to as stereoscopic aerials). The stereoscopic aerials provided the ability to identify, delineate and classify wetland types at a scale of 1:25,000. Additionally, stereoscopic aerials were a resource for estimating wetland vegetation disturbance, vegetation cover, and remnant vegetation.

Volume 2a provides detailed description and justification for the geomorphic classification system which has been adopted for this study. A full description of classifications is given above in Section 3.1.

Volume 2b of *Wetlands of the Swan Coastal Plain – Wetland Atlas* is a series of 52, 1:50,000 scale plans showing the extent, type and management category of each mapped wetland. A number of key attributes are also provided in table format for each wetland. Since the original publication of Volume 2b the wetland



mapping has been converted into a digital format for use in a geographic information system (the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset).

The evaluation of wetlands is the process used to describe and weigh a wetland's existing values. Management and planning objectives can be derived from wetland evaluation as it provides values, characteristics, function, use and attributes of each wetland. The evaluation of wetlands is not included as part of this study.

#### 3.3 WETLANDS CONSERVATION POLICY FOR WESTERN AUSTRALIA

The *Wetlands Conservation Policy for Western Australia* (Government of WA, 1997) outlines the State's commitment to identifying, maintaining and managing wetland resources.

The Policy consists of five principal objectives with respect to the conservation of wetlands:

- 1. To prevent further loss or degradation of valuable wetlands and wetland types, and promote wetland conservation, creation and restoration.
- 2. To include viable representatives of all major wetland types and key wildlife habitats and associated flora and fauna within a Statewide network of appropriately located and managed conservation reserves which ensure the continued survival of species, ecosystems, and ecological functions.
- 3. To maintain, in viable wild populations, the species and genetic diversity of wetland-dependent flora and fauna.
- 4. To maintain the abundance of waterbird populations, particularly migratory species.
- 5. To greatly increase community awareness and appreciation of the many values of wetlands and the importance of sound management of the wetlands and their catchments in the maintenance of those values.

This project is consistent with this policy as it seeks to represent and identify wetland types as a contribution to facilitate the specified objectives being met.

#### 3.4 FRAMEWORK FOR MAPPING, CLASSIFICATION AND EVALUATION OF WETLANDS IN WESTERN AUSTRALIA

The DEC has established a draft framework for the mapping, classification and evaluation of wetlands in the State to document wetland resources, identify



wetland values, and ensure the preservation and improved management of wetlands in the long-term.

The framework provides information relating to the levels of detail expected at the three stages of assessment. The three stages range from broad to detailed and are generally described below:

- Stage 1 assessment refers to the broad scale identification of the occurrence of wetlands within a study area to provide approximate boundaries and basic mapping of the wetland resource.
- Stage 2 assessment includes the identification of preliminary wetland boundaries, classification of wetlands into geomorphic types and identification of groups of wetlands (such as consanguineous suites).
- Stage 3 assessment involves collection of information on wetland attributes and functions including detailed mapping of wetland boundaries and site specific evaluation.

The mapping and classification done as part of this Study is commensurate with a Stage 2 level. In this Study an evaluation of each wetland will not be undertaken. The framework also describes relevant datasets to allow the classification and mapping of wetlands including information regarding landform, water permanence, sediments, approximate boundary, water quality, extent and condition of all wetland vegetation, use by aquatic and terrestrial fauna, degree of naturalness, and proximity to other wetlands.

The framework also identifies the system for wetland classification as being the geomorphic classification system described by Semeniuk & Semeniuk (1995), as described above in Section 3.1.



# 4 METHODOLOGY

The wetland mapping and classification process for this project was developed based on the capacity of geographic information systems for displaying, managing, analysing and creating geographic information. The methodology undertaken as part of this study represents a shift in the State's approach to mapping of wetland boundaries in WA as it moves into a digital approach rather than focusing on the manual use of hard copy information.

ENV adopted the following general approach to mapping wetland boundaries:

- 1. Analysis of remotely sensed satellite imagery for preliminary wetland boundaries over Area D.
- 2. Analysis of associated spatial datasets including digital aerial orthophotos, topography, soil types, remnant vegetation, and hydrography to map preliminary wetland boundaries for approximately 10% of Area D.
- 3. Verification of mapped wetland boundaries with the use of stereoscopic aerials.
- 4. Preliminary field survey to assess wetland-mapping methodology.
- 5. Revision of desktop mapping methodology based on findings of the field survey.
- 6. Desktop mapping of remaining wetlands using digital imagery and datasets outlined in steps 1 and 2.
- 7. Final field survey to assess the methodology undertaken for the desktop mapping, and to visit approximately 10% of identified wetlands in the field.
- 8. Minor adjustments based on outcomes of field survey.

#### 4.1 DIGITAL MAPPING

#### 4.1.1 **Principles of Geographic Data**

The mapping and classification of wetlands in Area D marks a shift in the methodology for wetland mapping that has been previously undertaken in WA commensurate with a Stage 2 as it involves the use of digital geographic data as part of the wetland mapping methodology.

Geographic information systems (GIS) are a class of information system that keep track of not only events, activities, and descriptions but also consider **where** these occur. Discrete data stored in a GIS has two main components: the vector



data and the attributes. The vector data holds the spatial location of the feature including its extent, boundaries, and geometry whilst the attribute information is stored in tabular format and relates to each shape or spatial feature mapped.

For this mapping project ESRI ArcGIS Desktop software was used and all results are presented in Map Grid of Australia (MGA) 1994 Zone 50 coordinates, referenced to the Geocentric Datum of Australia.

#### Representative Fraction/Scale

The representative fraction, also often known as the scale, is defined for a paper map as the ratio between distance on the map and the corresponding distance on the ground.

Representative fractions associated with standard map series, such as the 1:25,000 topography in Western Australia have become standard bases for description of maps and map users have become accustomed to the link between representative fraction and the types of features and level of detail shown in maps.

Previous wetland mapping effort in south-west Western Australia have been focused on the digitising of map boundaries at a scale of 1:25,000.

#### Spatial Resolution

In digital mapping, there is no comparable distance on the ground and instead we look to a degree of generalization that is valid for digital datasets to estimate accuracy such as spatial resolution.

The spatial resolution of a dataset is defined as the minimum distance over which change is recorded (Longley et al, 2001). Spatial resolution is often used to define the accuracy of a dataset, providing a margin of error. This term is often used to describe the accuracy in continuous datasets such as satellite imagery or digital aerial photography.

#### 4.1.2 Remote Sensing

An analysis of remote sensing imagery was used to identify wetland areas and to provide baseline wetland boundaries to a spatial resolution of 30 m.

Remote sensing refers to "the science of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area or phenomenon under investigation" (Lillesand & Keifer, 1994). Spaceborne satellite platforms use a series of sensors to record variations in the way the earth's surface reflects energy as different surfaces reflect a signature energy wavelength. This data can then be used to make assumptions regarding the composition of the earth's surface.



Remotely sensed satellite imagery is commonly used to determine land cover and land use over the earth's surface. The DEC currently monitors land clearing and salinity over the State through analysis of remotely sensed satellite imagery. Landsat 7 is a sensor onboard a spaceborne satellite that captures 7 bands of data across the electromagnetic range. Landsat 7 satellite imagery for the Study Area was analysed to determine preliminary wetland boundaries. Imagery from summer 1996 was used in the indices described below.

The use of indices in remote sensing compares the difference between two spectral bands to isolate the variation within a given phenomena. Two indices were applied to the remote sensing imagery to determine wetland areas.

The Normalised Difference Water Index (NDWI) was applied to the dataset to determine areas where open water was present. This index enhances water features in the imagery by comparing the green and infrared bands in the electromagnetic spectrum to maximise the reflectance of water bodies. This index is commonly used in baseline wetland mapping in Queensland (Queensland Government, 2007).

The Normalised Difference Vegetation Index (NDVI) was utilised to determine areas where vegetation health or "greenness" was determined. This index compares the red and infrared bands to enhance areas of high vegetation health. It was assumed that areas with a high level of greenness would be wetland areas. NDVI is commonly used to detect changes in wetland boundaries over time (Lillesand and Kiefer, 1994). ENV determined the NDVI for the project area but found that it was of limited use for identifying wetland boundaries.

The use of remote sensing imagery allowed ENV to identify wetlands that were of a significant size and had open water bodies such as lakes and rivers but waterlogged wetland types were underrepresented. Also, wetlands mapped using remote sensing techniques had to be greater than 90m<sup>2</sup> to be detected, therefore small wetlands were not captured.

#### 4.1.3 Analysis of Spatial Datasets

Spatial datasets were used to verify wetland areas identified using remote sensing and to identify potential omissions, and to verify and refine wetland boundaries.

In a GIS, the ability to overlay spatial datasets allows the user to compare the boundaries of separately occurring phenomena to determine their relationship and influence on wetland areas. Spatial datasets formed a background of detail that can be manipulated, analysed and adjusted to determine wetland boundaries. These datasets could be used to identify wetlands and define their boundaries. Datasets compared include topography, surface water catchments, soils, vegetation and digital aerial orthophotos (herein referred to as



orthophotos). A complete list of the spatial datasets is provided in Table 2 (information and metadata supplied by DEC).

Table	2:	Spatial	Datasets
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File Name	File Type	Year of Capture	Accuracy (m)	Resolution (m)	Source		
Digital Aerial Orthophotos							
Darkan_2231_Apr_May _June_2003_Mosaic	ecw	2003	5	50	Landgate		
Dinninup_2230_Nov_2004	ecw	2004	10	50	Landgate		
Darkan_2231_Jan_2005	ecw	2005	5	50	Landgate		
Darkan_2231_Mar_2006	ecw	2006	5	50	Landgate		
Dinninup_2230_Feb_2007	ecw	2007	-	-	Landgate		
Darkan_2231_Feb_2008	ecw	2008	-	-	Landgate		
Miscellaneous Shapefiles							
Soil_subsystems	shp	2001	250	-	DAg		
Veg_complexes	shp	1996	-	-	CALM <sup>1</sup>		
Drainage_lines	shp	2003	140	-	Geoscience Australia		
Waterbodies	shp	-	-	-	-		
Catchments	shp	2007	-	-	DoW <sup>2</sup>		
Sub_catchments	shp	2007	-	-	DoW		
Groundwater_bores	xls	-	-	-	DoW		
2m Derived Topography							
2230_14	shp	-	-	-	DAg <sup>3</sup>		
2230_23	shp	-	-	-	DAg		
2231_14	shp	-	-	-	DAg		
2231_23	shp	-	-	-	DAg		

Conservation and Land Management (CALM) 1.

2. 3. Department of Water (DoW) Department of Agriculture (DAg)



#### 4.1.4 Stereoscopic Aerial Pair Photographs

Stereoscopic aerials were used to potentially uncover any wetland areas that may have been omitted, to modify the boundaries to account for any differences and/or to assess the geomorphic classification given.

Stereoscopic aerials analysed for this study were from the Darkan (2231) and Dinninup (2230) map sheets and were represented as 11 flight runs across Area D in an east-west direction consisting of approximately 18 photos within each flight run. Only 1 set of stereoscopic aerials was used for this study with the flight runs being undertaken during October-November of 1996.

Previous comparable wetland mapping projects in the SW have used, stereoscopic pairs as the primary reference tool to delineate boundaries, with these boundaries then being transcribed to overlay paper before being manually digitised to form the GIS dataset.

In this study, the use of stereoscopic pairs has been used as an additional data source to assess the data. After the boundaries have been determined using the remote sensing and spatial datasets the area has been reviewed with stereoscopic aerials to potentially uncover any other areas that may have been omitted, to modify the boundaries to account for any differences and/or to assess the geomorphic classification given. The ability to view the land surface in three dimensions has been identified as helpful in previous work to assess the landform shape and wetland boundaries. This step has been included in the methodology to provide consistency with previous wetland mapping exercises undertaken.

Using the stereoscopic aerials was not found to improve the quality of the mapping and few changes were made while reviewing stereoscopic aerials.

#### 4.1.5 Identification of Wetland Boundaries

Identification of wetland boundaries was performed in an iterative process involving the use of remote sensing data, spatial datasets and stereoscopic aerials.

The remote sensing imagery was initially able to provide baseline mapping at approximately 30 m spatial resolution (or pixel size) which indicated areas that had open water and/or had wetland vegetation. The minimum detectable area of change was 90m<sup>2</sup> for wetland boundaries, which was not considered suitable accuracy for this study. Satellite imagery provides a accuracy at a 1:100,000 scale mapping which would commensurate with a Stage 1 delineation according to the *Framework for mapping, classification and evaluation of Wetlands in Western Australia* (DEC, in publication)



The remote sensing derived baseline wetland boundaries were then overlaid with digital orthophotos, topography, soil mapping, hydrography, catchment mapping and vegetation complex mapping to compare areas that were likely to be wetlands and derive boundaries at a 1:25,000 scale.

Wetland boundaries were delineated by using the following three generalised criteria:

- Landform: Are the proposed wetland boundaries coincident with the topography and topographic changes in the area? Where is the proposed wetland within the catchment?
- Soil: Do the orthophotos and/or soil mapping indicate that hydric soils or waterlogged soils are present?
- Vegetation: Do the orthophotos and vegetation complex mapping provide an indication of the extent of wetland vegetation present within the wetland?

The boundary of each wetland was then mapped in the GIS as a polygon feature referenced off digital orthophotos. The use of digital orthophotos in this process provides a georeferenced link to the ground surface where the boundaries of the wetland may occur.

The boundaries of the wetlands were also compared over a number of years as multiple orthophotos taken in different years improved the temporal resolution of the wetland boundaries.

For each individual wetland the criteria of landform, soils and vegetation were considered and ranked in the attribute table associated with the shapefile in terms of which criteria provided the basis for the extent of the boundaries. This provided clarity in the mapping process for future dataset users.

Once the boundaries were digitally mapped, the operator checked for consistency with stereoscopic aerial pairs. Use of stereoscopic aerial pairs was included in this project to provide some consistency with previous mapping undertaken in WA as it was the primary data source used. The advantage of using stereoscopic aerial pairs for this study was that they were all taken during October and clearly showed the seasonal extent of waterlogging and inundation.

In this study, a conservative approach to wetland delineation was adopted consistent with Semeniuk & Semeniuk (1995) where "the boundary of (a) wetland is drawn at the outside of the area that has the characteristics of dampness, or hydric soils, or vegetation indicative of wetland conditions".



#### 4.1.6 Classification of Wetlands

Once wetland boundaries were mapped a wetland type was then assigned to the area. The classification of wetlands into types using the geomorphic classification system is dependent on two main factors; landform and water permanence.

To determine the landform of each wetland the topography of the area and how that surrounding topography related to the shape of the wetland was considered. Figure 4 shows in diagrammatic form along with topographic contour line examples, the different landform types that are associated with wetland classification.

Water permanence was inferred through the use of orthophotos and stereoscopic aerials. The majority of the digital orthophotos used were taken during the summer months which is when seasonally inundated/waterlogged areas can be distinguished from permanently inundated areas as their drying regime is revealed. The stereoscopic pairs used for the site were all taken during winter months, which more clearly showed patterns of seasonal inundation and seasonal waterlogging.

In wetlands, the extent of seasonal inundation/waterlogging is often not consistent across the entire wetland area. Therefore classification of wetlands requires an assumption about the extent to which the water permanence can vary. Generally, wetland mapping in this study adopted the 10% cut-off rule proposed by Semeniuk & Semeniuk (1995) to distinguish between water permanences for a particular landform type. That is, the areas' extent of either permanent inundation or seasonal inundation cannot exceed either seasonal inundation or seasonal waterlogging respectively by greater than 10% and still maintain its original classification. The example given in Semeniuk & Semeniuk (1995) is as follows:

"If a basin that has a seasonally fluctuating water level dries out such that there is still more than 10% of water by area in the basin at the driest stage, then it is a lake, but if there is less than 10% of water by area in the basin at the driest stage, then it is a sumpland" (p.111).

Additionally, for distinction of channel wetland boundaries some generalisations are made between classification types. Channels can be very narrow in their extent and therefore difficult to recognise at a scale of 1:25,000. The following approach was undertaken:

1. A system of small 'braided' channels was grouped together into a single channel system.



- 2. An extensive floodplain or palusplain with a small channel within its area may be mapped as a single 'floodplain' entity as the channel is too small to be recognized at the scale of mapping.
- 3. A channel may have an additional flat area of riparian vegetation mapped as part of the channel as the flat area is too narrow to be identified as a floodplain or palusplain.

#### 4.2 FIELD SURVEY

Field survey was used in this study to provide an assessment of the applicability of the methodology in the early stages in the mapping process and to provide a measure of accuracy to associate with the finalised mapping dataset.

#### 4.2.1 Site Visits

This study undertook two separate field surveys to assess the desktop mapping methodology.

A preliminary field survey was undertaken by an Environmental Scientist and a Botanist from ENV on 5-6 May 2009 to examine selected wetlands in the northern part of Area D.

A variety of wetlands were chosen for this visit to ground truth the mapping methodology and to gain a practical understanding of the physical environment and the characteristics of the catchment. During this first field visit approximately 10% of Area D had been mapped using the desktop methods.

The wetlands visited during this first field survey represented the range of types and varied in their composition including whether their surrounding area had been cleared or consisted of remnant vegetation. ENV staff examined the soil hydrological conditions, and landform types, vegetation, for wetland Wetland boundaries and classifications were assessed to characteristics. provide feedback into the desktop mapping methodology and are not considered as part of the final accuracy statement. How wetland boundaries were determined and classification methodology is described below.

During the first field visit, sites were selected where either the existence of a wetland was questionable or the boundaries of a wetland were not clearly distinguished in the desktop mapping. This ground truthing was undertaken to gain some confidence in the desktop mapping methodology.



The second field survey was performed between 8 –15 June 2009 and examined a wider extent of Area D focusing on visiting a minimum of 10 wetlands within each 1:25,000 map grid area (Figure 1).

The field survey areas selected were based on accessibility and based on diversity of wetland types within the area. Wetlands were predominantly located on private property and as a result, 30 proprietors were contacted for permission to survey wetlands. In some cases, access was denied to the property or proprietors could not be contacted. Field maps showing the wetlands visited are contained in Appendix A and the photos are provided as the digital Attachment 1 to this study.

For each wetland visited a field sheet was compiled with observations regarding the vegetation, hydrology, soils and landform in the area and how it related to the mapped boundaries of the wetland and its classification. The field sheets associated with each wetland visited are found in Appendix B. In addition a number of photographs were taken at each wetland, an index of the photographs is included as Appendix C.

#### 4.2.2 Identification of Wetland Boundaries

Identification of wetland boundaries in the field focused on determining the extent of waterlogged or seasonally inundated areas based on the hydrology, landform, hydric soils, waterlogged soils and wetland vegetation.

To capture the position of the wetland boundary as determined in the field ENV staff were equipped with a handheld global positioning system (GPS) to record coordinate locations. These coordinate locations could then be loaded into the GIS on returning to the office and directly compared to the derived desktop boundary.

When ENV staff were on site they determined where to record coordinates using two methods; a transect and/or a "boundary walk".

Transects were used to determine the boundary of wetland vegetation and hydric soils. One or two transects were walked in a consistent direction beginning in a clearly dryland area towards an anticipated wetland boundary taking note of changes within the composition of vegetation and collecting soil samples.

In areas where wetland vegetation was present, a GPS coordinate was recorded at the transition point to dryland species to delineate the wetland boundary. Facultative vegetation alone, however, are not significant in terms of delineating boundaries of wetlands. In situations like these supplementary information on the hydrology, landform and hydric soils was required.



In this study, a boundary walk refers to walking along the edge of the boundary to a wetland. During a boundary walk up to five GPS coordinates were recorded at approximately 10-20m intervals depending on access. A boundary walk was used in this study where there was a clear and distinct transition between wetland and dryland areas.

For each wetland it was endeavoured to perform one boundary walk, if distinct boundaries were observed. When wetland boundaries were not easily distinguishable 1 or 2 transects were undertaken. Boundaries were determined by either a boundary walked or up to 2 transects per wetland.

Described below is how the boundaries were determined based on vegetation, soils, hydrology and landform.

#### Vegetation

The majority of Area D has been cleared for agricultural purposes and wetlands have been grazed by stock, therefore the use of vegetation as a boundary identifier is limited.

During the first field visit where vegetation was present and field identification of plant taxa was not possible, specimens were collected systematically for later identification by a specialised taxonomist. Literature research was then undertaken using the West Australian Herbarium's *Flora Base* (Western Australian Herbarium, 2009) to confirm species habitat preference.

Based on the literature review using *Flora Base*, species that prefer winter-wet areas, swamp areas, creek lines, waterlogged soils, etc. were considered wetland obligate species (i.e. those plants generally restricted to wetland habitats, DEC 2007a). Facultative species can be common, notably in a variety of habitats such as hills, slopes as well as beside drainage lines, fringing salt marshes, etc. (i.e. those species that can occur in wetland and dryland habitats, DEC 2007a).

After ENV botanist researched species habitat preference and identified specimens, field staff became familiar with the area's flora, further facilitating positive wetland boundary delineation. Any new flora species not found in the first survey were identified at the Shire's herbarium as required to aid in up-to-date field identification. Please note as this was not a comprehensive survey not all species present within the wetland community were recorded.

Species that were considered to be acting as obligate wetland species in the project area and that were recorded during the field surveys are listed in Table 3. A complete vegetation species list and their habitat preferences have been compiled in Appendix D.



Table 3: Study Area Wetland	d Obligate Flora Species List
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FAMILY		ТАХА		COMMON NAME
TYPHACEAE	*	Typha	orientalis	Bulrush
CYPERACEAE		Baumea	juncea	Bare Twig Rush
		Ficinia	nodosa	Knotted Club Rush
		Gahnia	trifida	Coastal Saw Sedge
RESTIONACEAE		Lepidosperma	sp.	
JUNCACEAE		Juncus	pallidus	Pale Rush
CHENOPODIACEAE		Tecticornia	lepidosperma	
MYRTACEAE		Melaleuca	cuticularis	Saltwater Paperbark
		Melaleuca	lateritia	Robin Redbreast Bush
		Melaleuca	preissiana	Moonah
		Melaleuca	rhaphiophylla	Swamp Paperbark
		Melaleuca	ssp.	
		Melaleuca	viminea	
		Verticordia	densiflora	Compacted
SOLANACEAE	*	Solanum	nigrum	Black Berry Nightshade
ASTERACEAE	*	Conyza	sp.	-
	*	Sonchus	asper	Rough Sowthistle

#### Abbreviations:

sp.: species (singular) var.: variety

spp.: species (plural) subsp.: subspecies

\* denotes foreign introduced species

ms: manuscript name (unpublished)

#### Soils

Field observations were made regarding the presence of hydric soils and/or evidence of waterlogged or inundated soils.

Hydric soils are defined as "soil that has formed under conditions of saturation, flooding or ponding long enough to develop anaerobic conditions in the upper part. The concept of hydric soils includes soils developed under sufficiently wet



condition to support the growth and regeneration of hydrophytic vegetation" (DEC, in publication).

At each site the soil conditions at surface and subsurface were noted. Analysis of subsurface soils was done by hand augering to approximately 0.5m depth. This depth was considered adequate as groundwater rise to this level would cause waterlogging at surface due to the capillary fringe. Hand augered and surface samples were observed in the field for properties of hydric soils and/or waterlogging to determine wetland boundaries. Soil samples were returned to ENV offices and visually analysed by an ENV Senior Geochemist. Indicators of hydric soils examined include texture, colour, organic content, structure, mottling, and moisture content.

Groundwater was not encountered at any location by hand auger however, groundwater was observed in nearby table drains and surface water drains. Additionally, in areas that had been affected by salinity from groundwater rise there are separately noted soil conditions and a pattern of dead or dying vegetation. Salt affected areas are generally characterised in Area D by a limited amount of vegetation.

Observations are noted in the "soil assessment" section of the field notes.

Where appropriate, wetland boundaries were determined and boundary walks were undertaken at the extent of the hydric soil area as noted in the field notes.

#### Hydrology

Hydrological observations made in the field related primarily to either surface water or groundwater hydrological characteristics. This includes evidence of groundwater rise, surface water inundation or surface water flow across the wetland.

Although a snapshot of the hydrology of a wetland cannot be used to define a wetland boundary it does contribute to either the landform type or the soils present therefore supporting the observations made. More importantly, understanding the hydrology of the wetland is imperative to its geomorphic classification.

#### Topography

Landform type is largely dependent on the local topography. Field observations of topography can provide a refinement of the information collected as part of the desktop works. Minor changes in relief and landform can be determined based on field observations.

For basin and channel type wetlands the boundary is largely determined by changes in landform and a clear shift between wetland soils and wetland vegetation is often due to changes in landform. When a boundary walk was undertaken the altitude from the GPS was also recorded (typical accuracy +/-5m).



Landform change was often identified as a boundary for a wetland as it often coincided with a change in soils, vegetation and/or hydrology.

#### 4.2.3 Classification of Wetlands

The classification of wetlands in the field was based on two key observations relating to the landform and water permanence.

Observations of landform type in the field were classified according to the landform types presented in Figure 4. A section in the field notes was dedicated to the observation of the landform type and how it related to the desktop mapping. For example, typical observations included identifying low lying or flat areas, basin formations in the landscape, a degree of erosion forming creek or river banks.

The water permanence in the field was identified through observations regarding the local hydrology and soils of the wetland. Since the site visit occurred in June, and not during a period of peak groundwater and surface water levels, a number of observations were recorded to estimate the extent of waterlogging or inundation that would characterise the wetland. Where waterlogging and surface water flow was observed it was noted in the field notes.

In seasonally dry wetlands, observations regarding soils and hydrology were recorded to make an estimate as to the "wetness" of the area. Observations regarding erosion or surface water scour in many wetlands were recorded to indicate seasonal inundation.



### 5 RESULTS

In Area D approximately 919 wetlands were mapped and classified including rivers, creeks, lakes, sumplands, damplands, floodplains, palusplains, and paluslopes using the methods described above.

Area D is comprised of approximately 27,000 ha of mapped wetlands which is approximately 19% of total project area. The majority of wetlands mapped were creeks, floodplains or palusplains. The breakdown of wetland classification types as a percent of total mapped wetland area is shown in Figure 5 below:

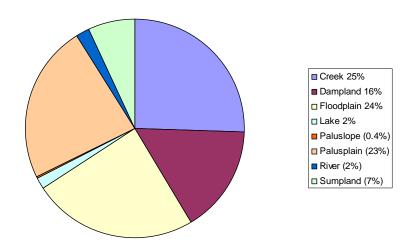


Figure 5: Wetland Type as Percent of Total Wetland Area

The field survey undertaken as part of this study visited 118 wetlands in total making up approximately 13% of the mapped wetlands. The boundaries of 73 wetlands were assessed in the field and boundary coordinate locations were captured and used to compile the accuracy statement. Typical accuracy on a handheld GPS is +/- 5m.

Based on field observations typical accuracy for the Area D wetlands spatial dataset was determined as approximately 21 m.

Based on the field observations, classification of the wetlands undertaken at a desktop level was confirmed and few wetlands required a change in classification.

All mapped wetlands have been provided as an ArcGIS shapefile in polygon format. Listed in the attribute table are a unique feature identifier, the geomorphic classification of each wetland, the criteria that defined the boundary, whether a site visit was conducted and the date of the site visit.



Metadata (data about data) has been compiled to describe the content, structure and general features of the Area D wetlands spatial dataset. The metadata for this dataset is contained in Appendix E. The spatial dataset is the digital Attachment 2 to this report.

It is envisaged that this report is to be read in conjunction with use of the wetland spatial dataset and related to field descriptions that are contained in Appendix B.



## 6 DISCUSSION

#### 6.1 DESKTOP MAPPING

This study employed a new methodology for desktop mapping and classification of wetland areas in Area D. This methodology was undertaken to take advantage of GIS and other spatial information collected in Area D by either the DEC or other State government agencies. The new methodology yielded a robust dataset that was ground truthed through field observations. Accuracy of 21m is considered to be an improvement on that recorded for previous wetland mapping and spatial data.

Channel wetlands were included as part of this study whereas they were not included in previous wetland mapping studies. This was an important inclusion for this dataset as the general hydrology of the area is dominated by surface water flow and it is the main driver for the water permanence of most wetlands encountered.

#### 6.1.1 Limitations

Generally in spatial analysis, datasets created are limited by the spatial datasets from which they are derived. In this study, the extent to which remotely sensed data could be utilised was limited by the coarse spatial resolution of the satellite imagery (30m resolution) and therefore requiring greater input based on the remaining spatial datasets. Spatial datasets including the topography, soils and vegetation complexes were at a coarser spatial resolution than the required output of this study. In other words, a GIS cannot derive a 1:25,000 dataset from input datasets that are derived at 1:100,000 as is generally the case from remote sensing data. In turn, the resultant boundaries are largely based on the finer resolution of the digital orthophotos.

The implication of this is that there is a greater emphasis and need for manual processes and operator adjustment and less focus on the information derived from spatial datasets introducing an element of subjectivity.

A further limitation was imposed by the orthophotos available for the area. The majority of the orthophotos provided were captured in the summer months and corresponding to dry conditions. Boundaries based on summer months may not correspond to those reached in the winter months or when water levels are at their peak (generally in September or October) and in turn, impacting on the accuracy of the boundaries.

As stated above, channel wetlands were an important inclusion in this dataset, however, as channels are formed by surface water flow and catchment characteristics, their boundaries are largely determined by topography and the



availability of refined topographic data for desktop mapping is therefore imperative. Field observations indicated that channel depths were generally less than 2m, therefore bank heights would be undefinable in 2m topography. As stated in the methodology, channel areas have been generalised to reflect the coarse 1:25,000 scale of the mapping but could have been generated at a much finer scale had better topographic information been available.

#### 6.1.2 Outcomes

Desktop mapping for this project was undertaken between April to June of 2009 and was submitted to the DEC as a digital file for review in a compatible GIS format. In this study, all mapping was undertaken by a single operator thus reducing the possibility of handling errors being introduced into the dataset.

Previously, wetland boundaries had been provided to the DEC as a series of hand drawn transparencies corresponding to wetland boundaries and DEC GIS operators were required to digitise these boundaries. Handling errors may be introduced as the boundaries are defined by one individual who is familiar with wetlands then transcribed by an operator without such familiarity. The methodology for this project recognised potential handling errors that could occur and endeavoured to minimise them.

A major advantage to computer based mapping is the ability to process a dataset in its entirety to identify areas that have specific characteristics. In this study, field observations could be translated to mapping rules that can be applied across the dataset. For example, if intergradations of landform types needed to be adjusted the operator could identify all wetlands in Area D where an intergradation occurred in less than 1 minute.

The operator could create rules in the dataset that had to be followed across the entire dataset. The advantage of this is it provides consistency across the dataset and a single change could be replicated throughout the entire dataset without any major time commitment.

Additionally, clarity was a key component of this project. Clarity in the process and methodology of wetland mapping has been provided to increase the repeatability in the project and improve the understanding of wetlands to potential users of this dataset. In each mapped wetland, criteria were provided in ascending order to indicate what phenomena (either vegetation, soils or landform) were considered to identify the boundary of the wetland. These criteria are listed in the attribute table for the shapefile and are given for each individual wetland.



#### 6.1.3 Recommendations

The use of GIS and spatial datasets in wetland mapping is recommended for future wetland mapping projects undertaken by the DEC. Using the GIS provides increased accuracy in determining the wetland boundaries and can incorporate a a number of different datasets to assist in identifying the other factors associated with wetland boundaries.

As mentioned above, this study was limited by the amount of fine scale spatial datasets available. It is recommended that future areas chosen for wetland mapping have refined topographic mapping available as almost 70% of wetland boundaries were defined in this study based on their landform characteristics. Topographic contour intervals of 0.5m would greatly improve the results. Alternatively, a collection of accurate and recent spatial data for areas to be mapped is recommended, similar to that listed in Table 2 above.

The use of stereoscopic aerials in this study was done to provide consistency between wetland mapping studies. However, using the stereoscopic aerials was not found to improve the quality of the mapping and few changes were made while reviewing stereoscopic aerials. The use of aerial orthophotographs provided the georeferencing for wetland locations and topographic mapping is then overlaid providing an impression of the landform. The ability to read topographic mapping is considered to be equivalent to viewing images through the stereoscope.

Also, the use of aerial orthophotos captured during the wetter months (September, October) should occur if they are available to determine the extent of potential wetland areas, particularly to capture seasonal inundation/waterlogging. Approximately 95% of wetlands in Area D are subject to a seasonal hydroperiod and having wet period aerial photography would help to refine those boundaries.

#### 6.2 FIELD SURVEY

The main goal for the field survey was to visit 10% of the mapped wetlands within Area D. In total, ENV visited approximately 13% of wetlands in Area D over 10 days. The field survey provided familiarisation with the catchment which then improved the outcomes in the mapping and provided an estimation of the accuracy in the dataset.

The field survey was an important part of the study as it confirmed that the methodology undertaken to identify, delineate and classify wetlands was appropriate.



#### 6.2.1 Limitations

Two main limitations were encountered in the field survey. Firstly, the field survey was done in June during early winter when groundwater levels are low and surface water levels are beginning to rise. The water permanence of approximately 95% the wetlands mapped are seasonally inundated or seasonally waterlogged. In this case, conclusions made regarding the hydrological regime of the wetland had to be determined based on vegetation, soil and local hydrology.

Secondly, Area D is predominantly freehold property, ENV had limited access on some blocks as the landholder was either unable to be contacted or refused entry. This affected the number of wetlands whose boundary conditions could be examined.

#### 6.2.2 Outcomes

The field survey exceeded the target for the number of wetlands to be visited in the field. This provides additional confidence in the accuracy statement provided.

The use of a transect and/or a boundary walk to identify wetland boundaries provided adequate detail to assess the accuracy of boundaries in the GIS. It is not documented in the literature what field procedures were used in previous wetland mapping studies. Understanding how previous field survey was undertaken would be valuable for comparing accuracy statements if this is the objective of the DEC.

For the field survey, detailed notes were compiled and have been submitted as Appendix A to this report. All notes refer to the unique feature identifier (UFI) that is contained within the Area D wetlands spatial dataset to link the spatial component of the project to the field component. GPS capture points and key elements of the boundary definition are noted to improve the repeatability of this study. Additionally, over 250 photos were taken in the field that identify boundary areas and support the observations documented in the notes.

### 6.2.3 Recommendations

A field survey to ground truth results from desktop mapping is an important part of the study and should be included in future projects. In future projects, the vegetation, soils, hydrology, and landforms associated with wetland boundaries that are observed in the field should be identified and described.

It is recommended that field survey methods are consistent and replicable across DEC wetland mapping projects. These should be formally outlined and subject to change based on temporal or environmental conditions based on the different areas that are assessed. Because the accuracy statement is based on the



outcomes of the field survey there should be a level of consistency across projects.

Furthermore, timing of the field survey should be coincident with peak water levels in the catchment. This would make the estimation of wetland boundaries far more accurate. It is understood that these boundaries are still variable year to year but it would at least capture the conditions during a seasonally wet period.

### 6.3 TEMPORAL RESOLUTION

Generally, mapping of wetland boundaries is not just limited to a spatial scale but also to a temporal scale. Environmental and climatic changes may occur that in turn cause alterations of wetland boundaries. Temporal resolution refers to the precision of measurement with respect to time (Lillesand & Kiefer, 1994)

The conditions on site are assumed to represent the last 10-15 years. Aerial photography used for wetland mapping also showed changes throughout the landscape over the last 12 years providing a benchmark for major environmental changes. In the aerial photography there were no significant shifts in wetland boundaries.



## 7 CONCLUSIONS

- ENV Australia Pty Ltd (ENV) was commissioned by DEC to undertake mapping and classification of wetlands for "Area D" within the Shire of West Arthur.
- This study is consistent with principles and guidelines in the *Framework* for *mapping, classification, and evaluation of wetlands in Western Australia* (DEC, in publication).
- In a desktop GIS, remote sensing data and the spatial datasets were overlayed and compared to determine what spatial locations were likely to be considered as wetland areas. A total of 919 wetlands were identified.
- Desktop identification of wetland boundaries was performed in an iterative process involving the use of remote sensing data, spatial datasets and stereoscopic aerials.
- Once wetland boundaries were mapped a geomorphic classification was then assigned to each identified wetland. The classification of a wetland is dependent on two main factors; landform and water permanence. The wetland types identified were rivers, creeks, lakes, sumplands, damplands, floodplains, palusplains and paluslopes.
- Field survey was used in this study to provide a measure of accuracy of the resultant mapping. Two field surveys were undertaken in this study over the course of 2 separate field trips with a total of 10 days in the field visiting approximately 118 wetland of which 73 had their boundaries scrutinized.
- The accuracy of wetland boundaries determined from the field survey visiting 73 wetlands is +/- 21m.
- The new methodology yielded a robust dataset that was ground truthed through field observations.



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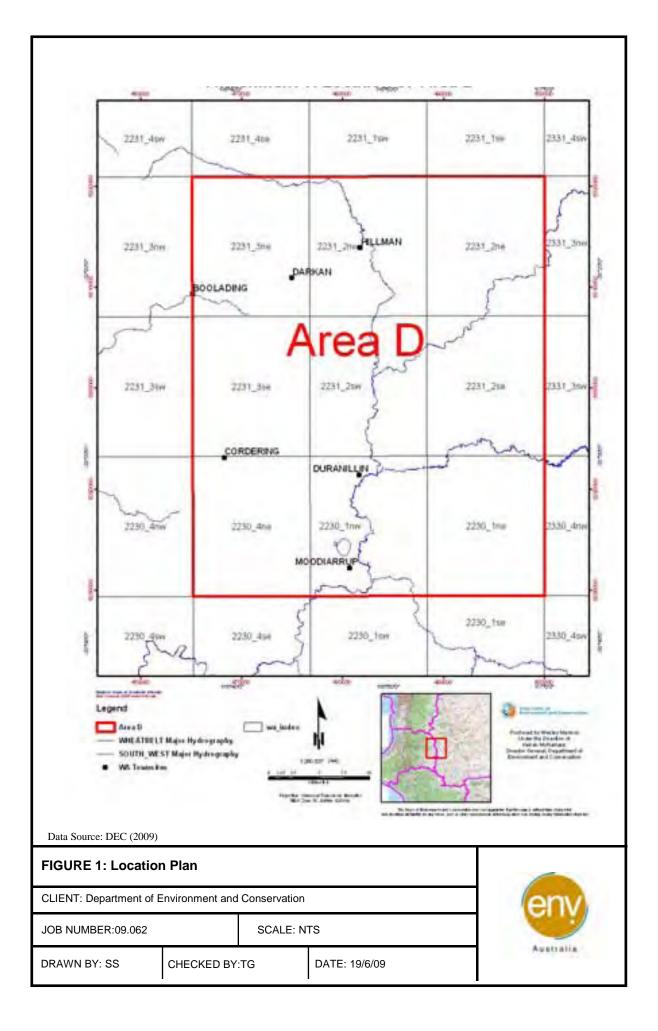
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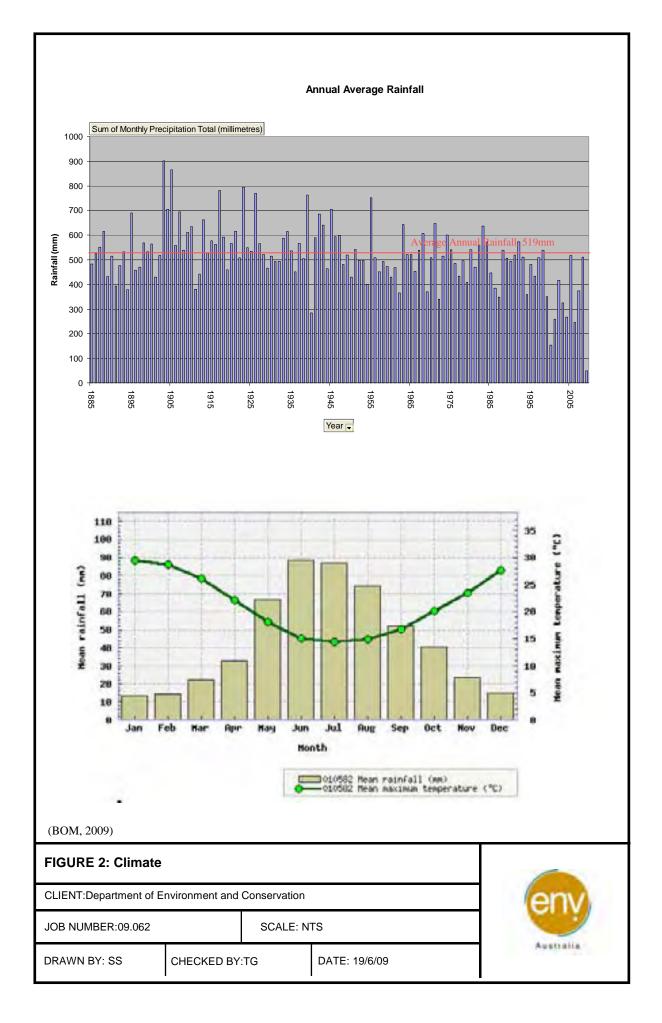
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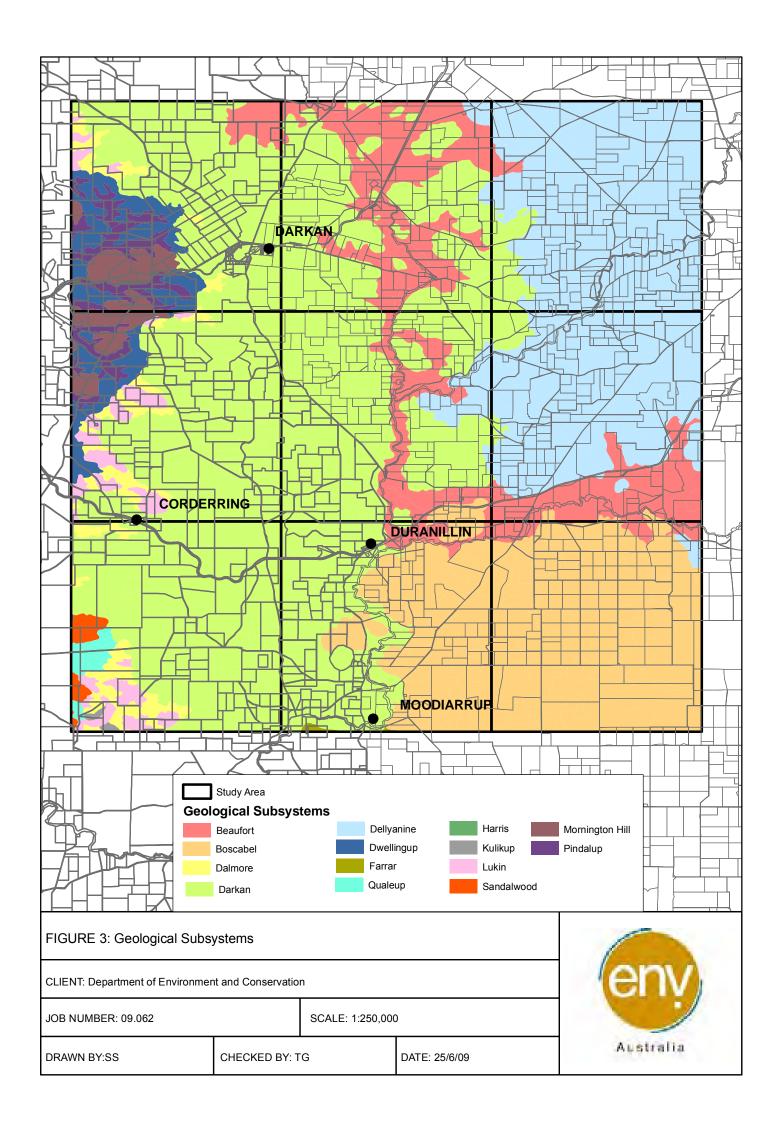


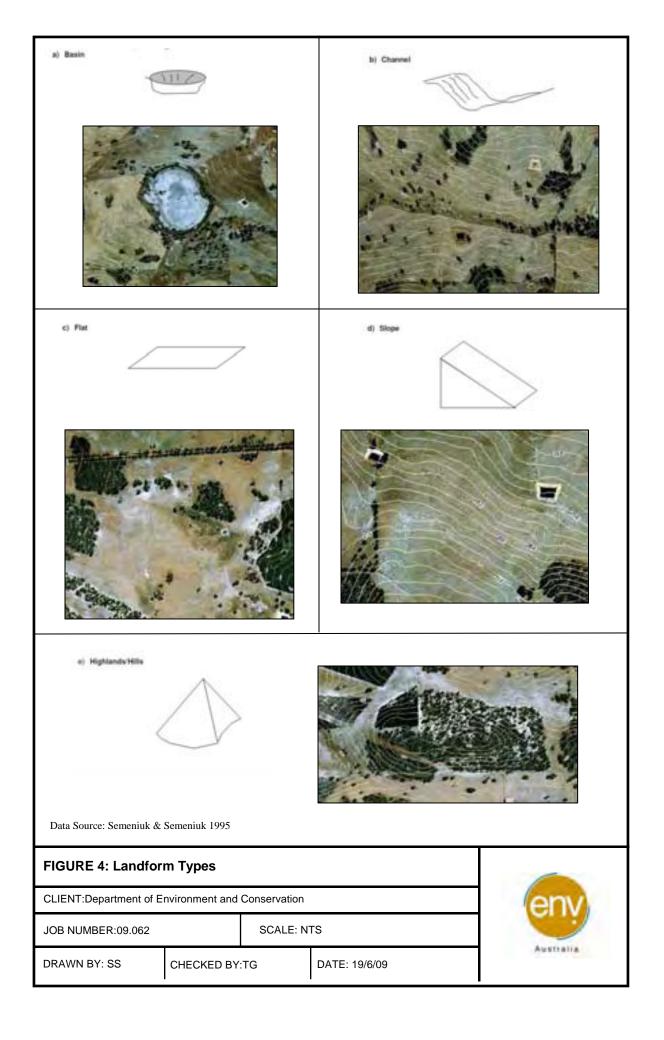
## FIGURES





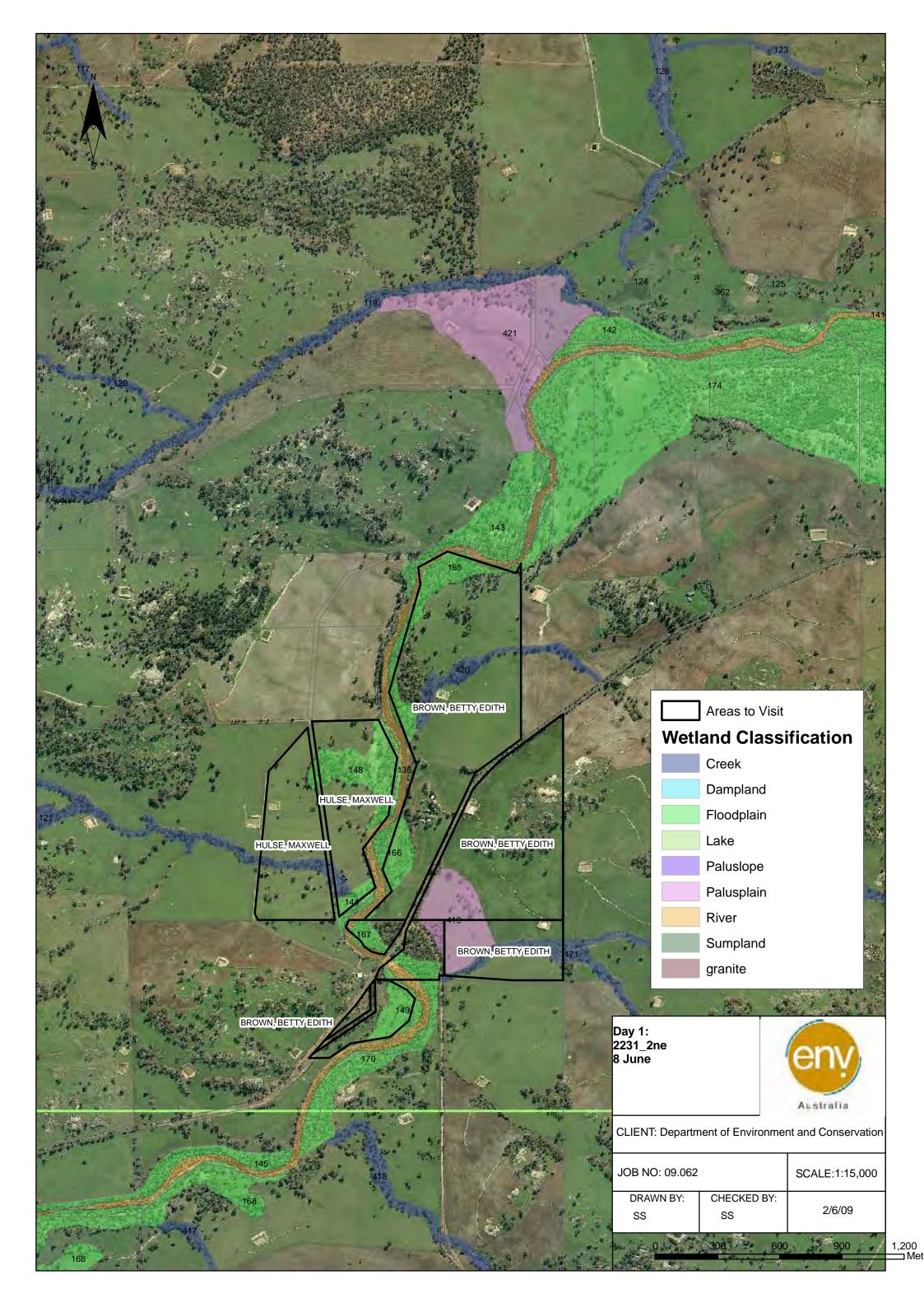


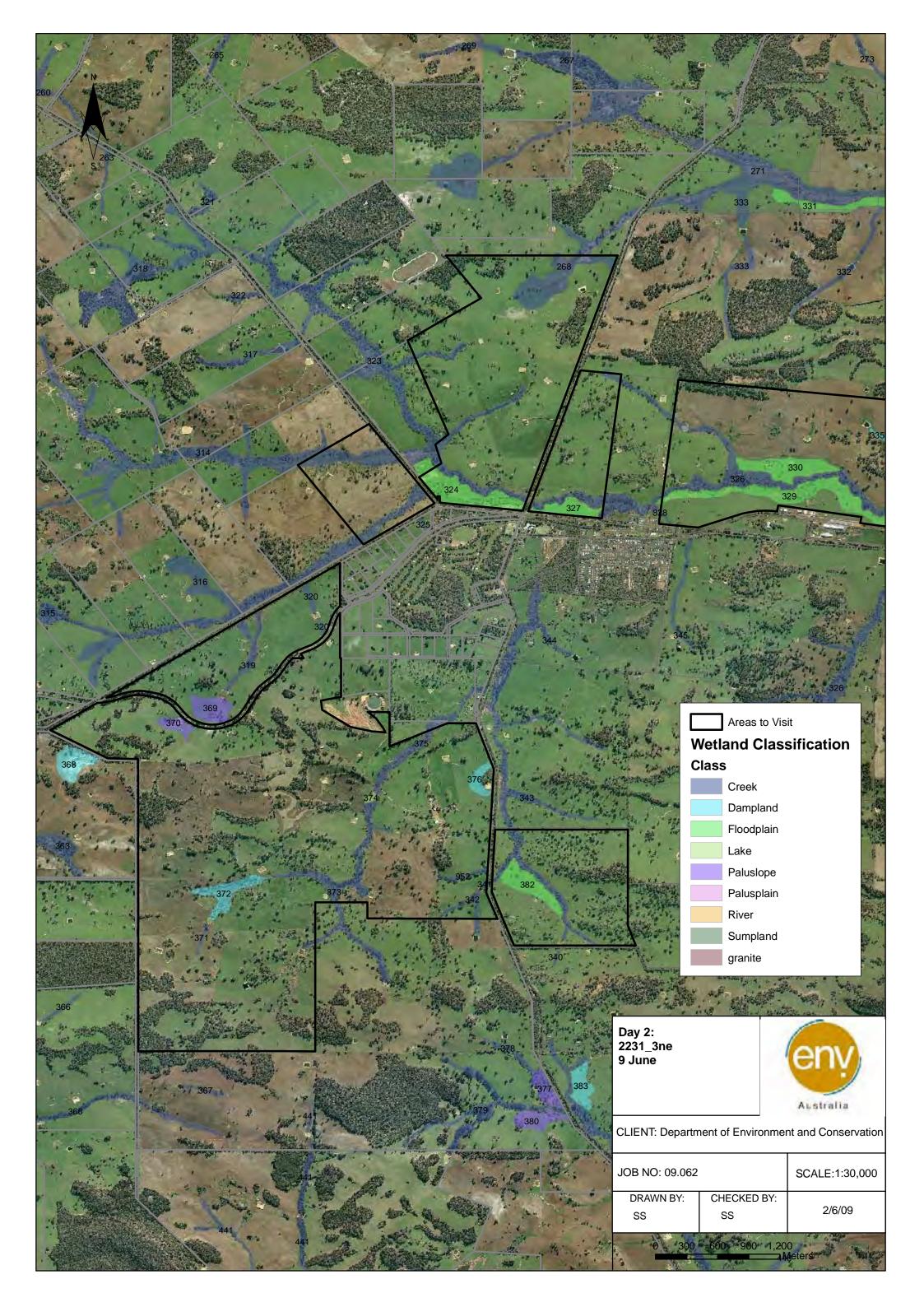


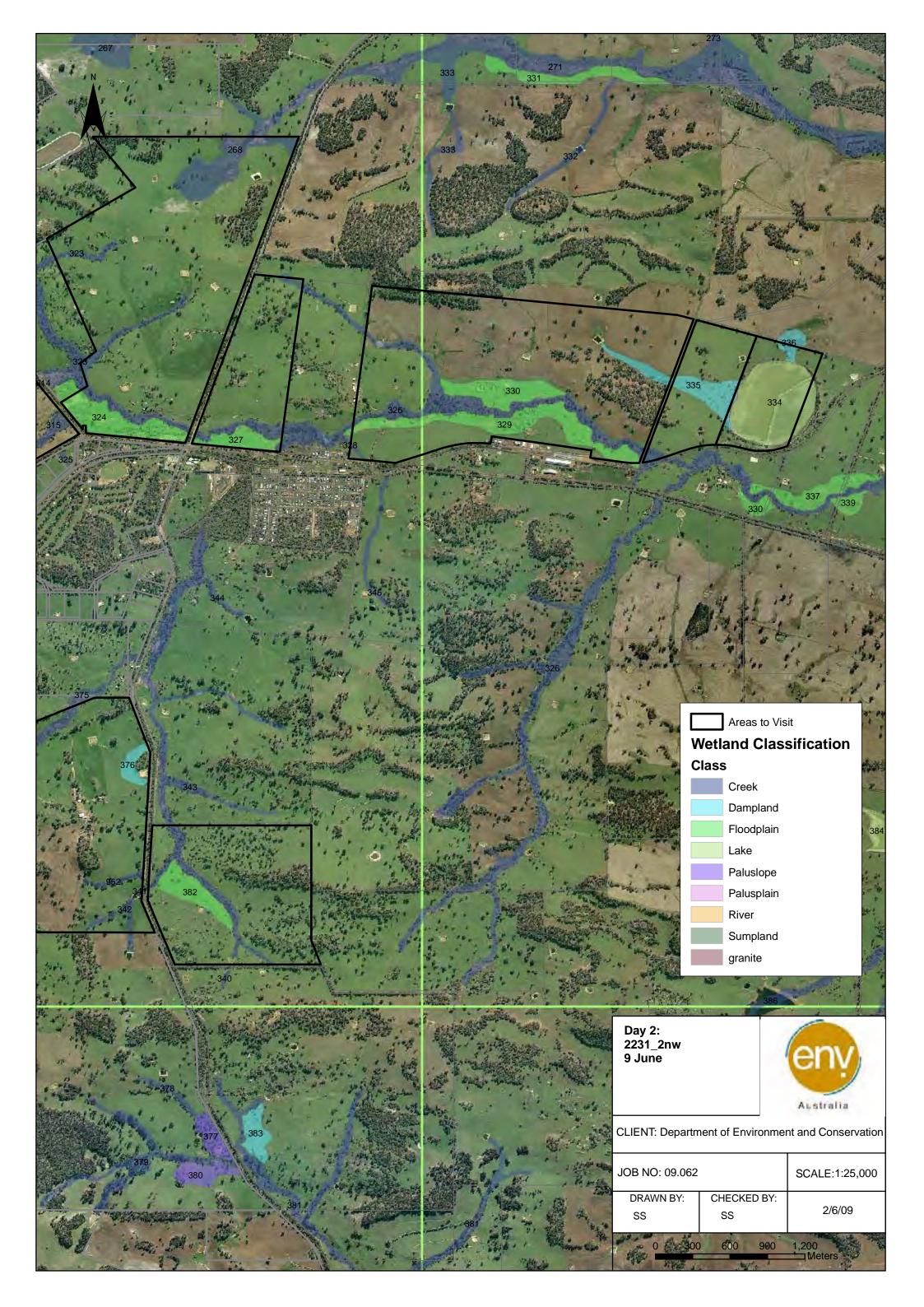


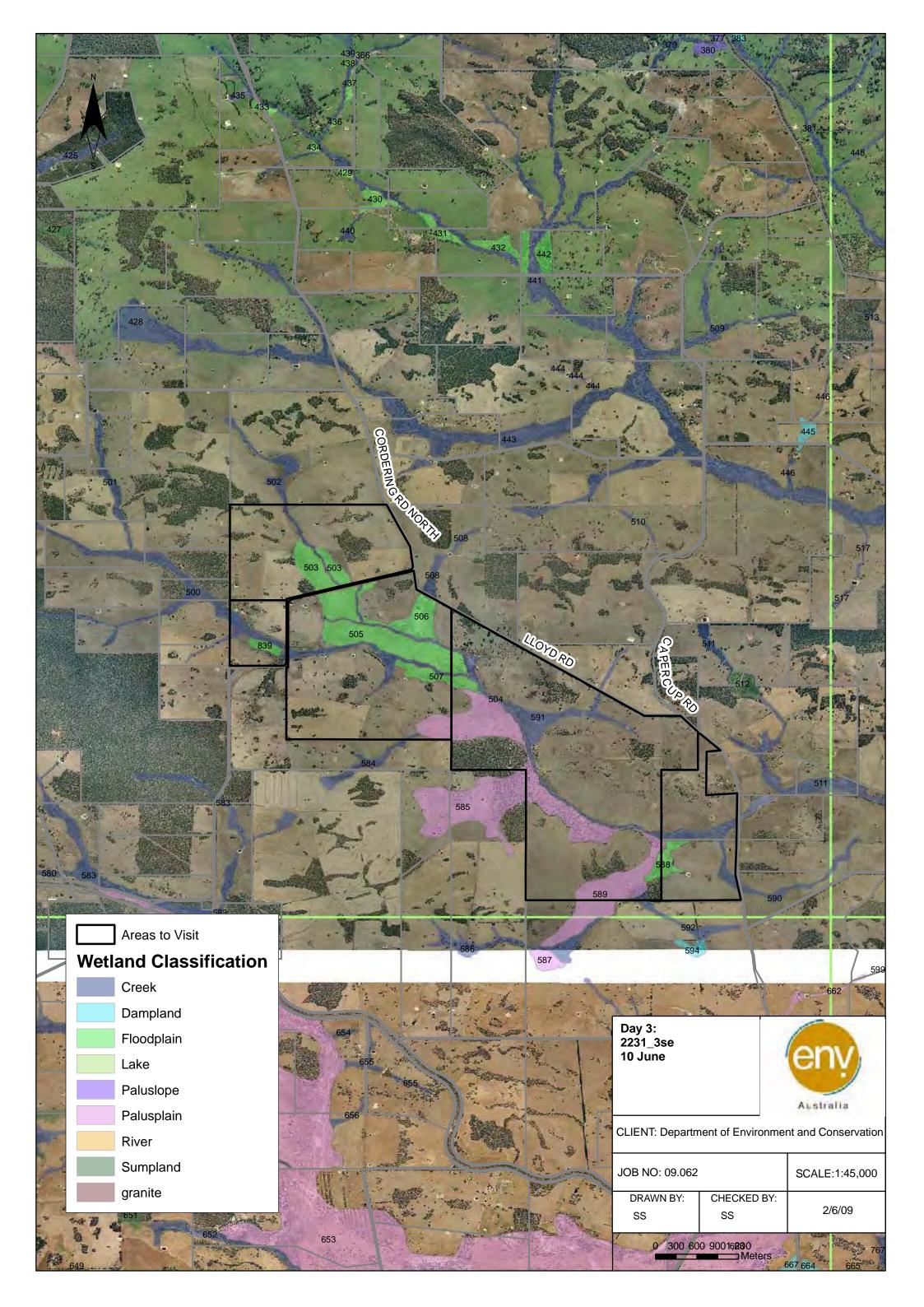
# APPENDIX A FIELD MAPS

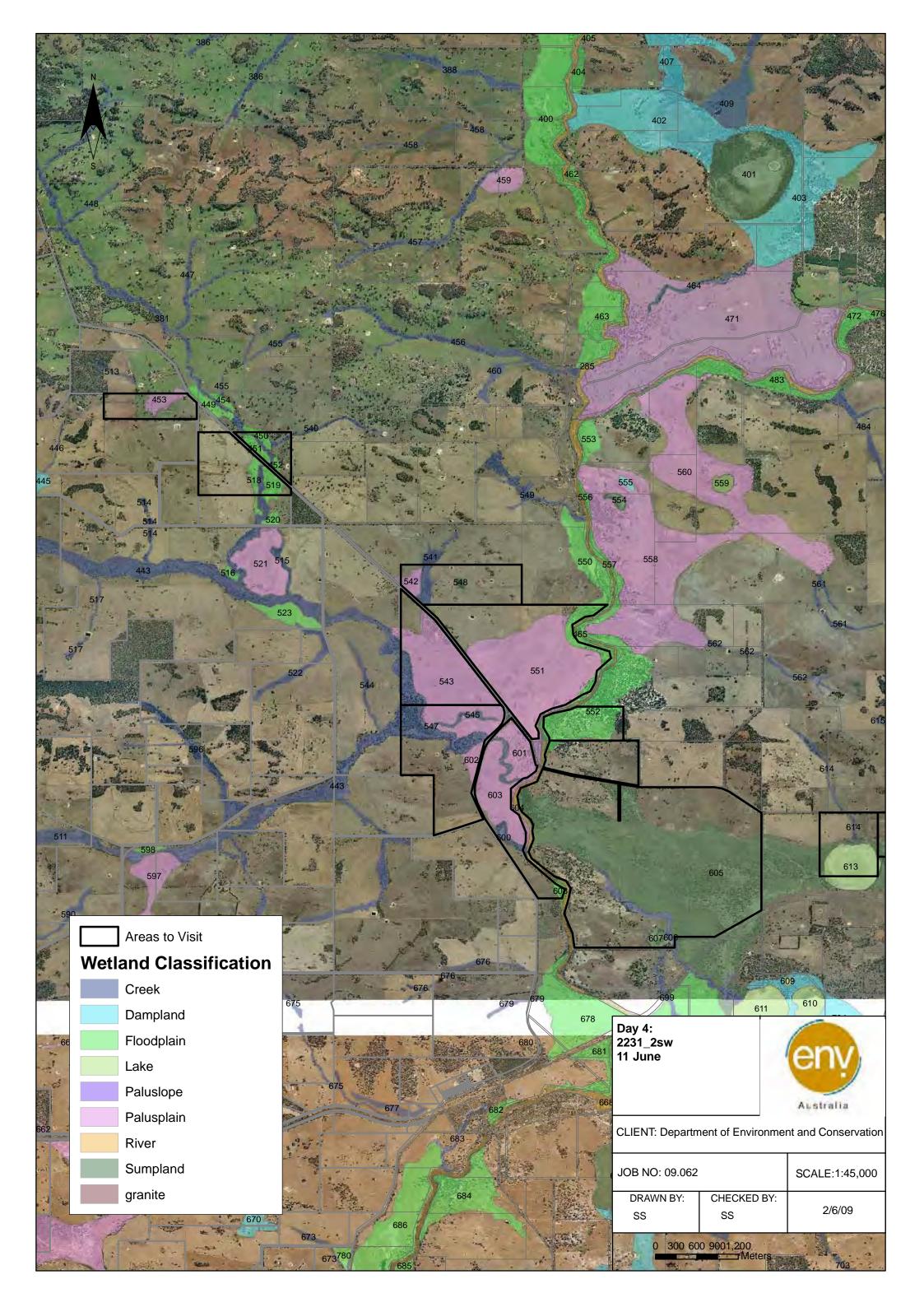


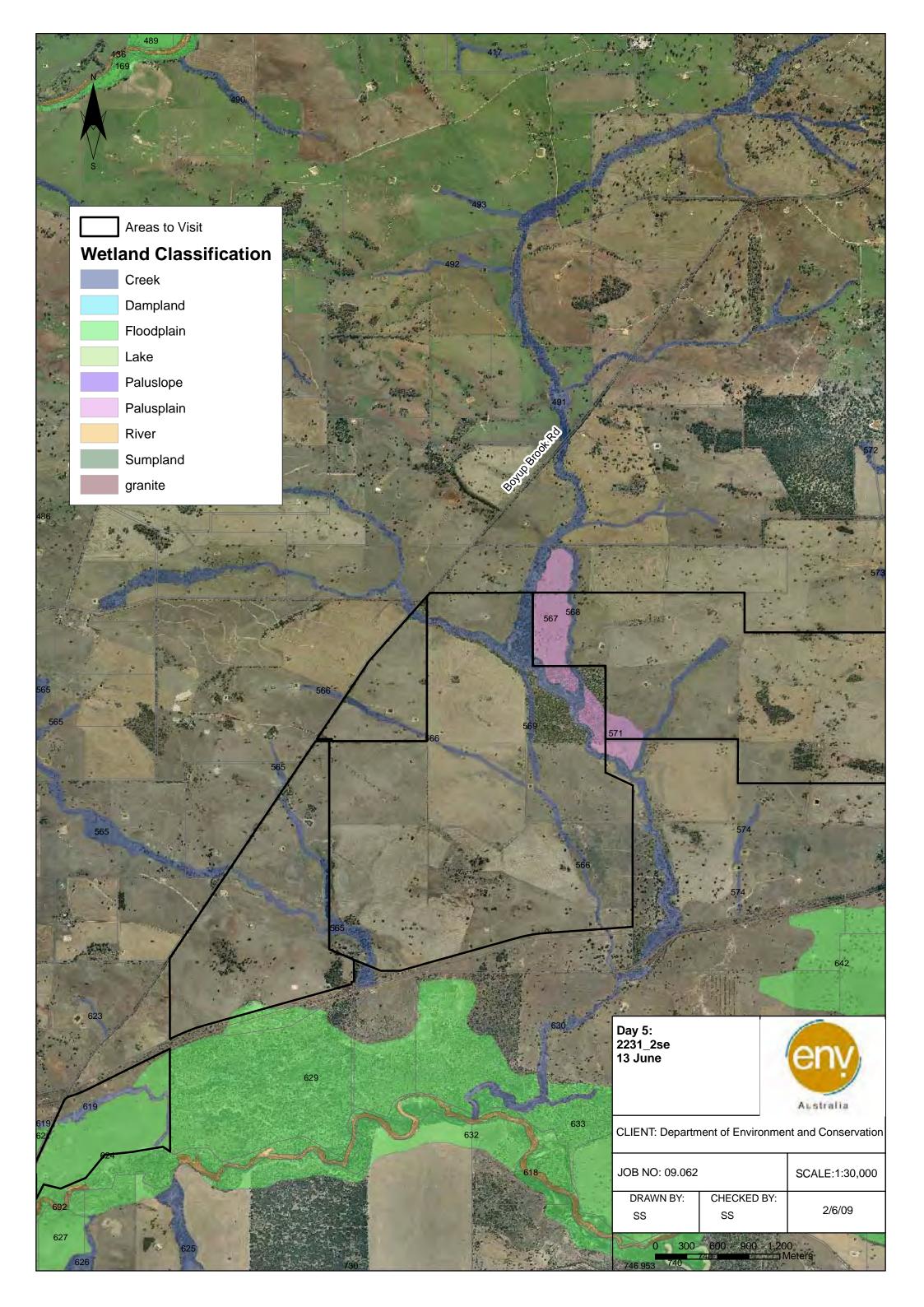


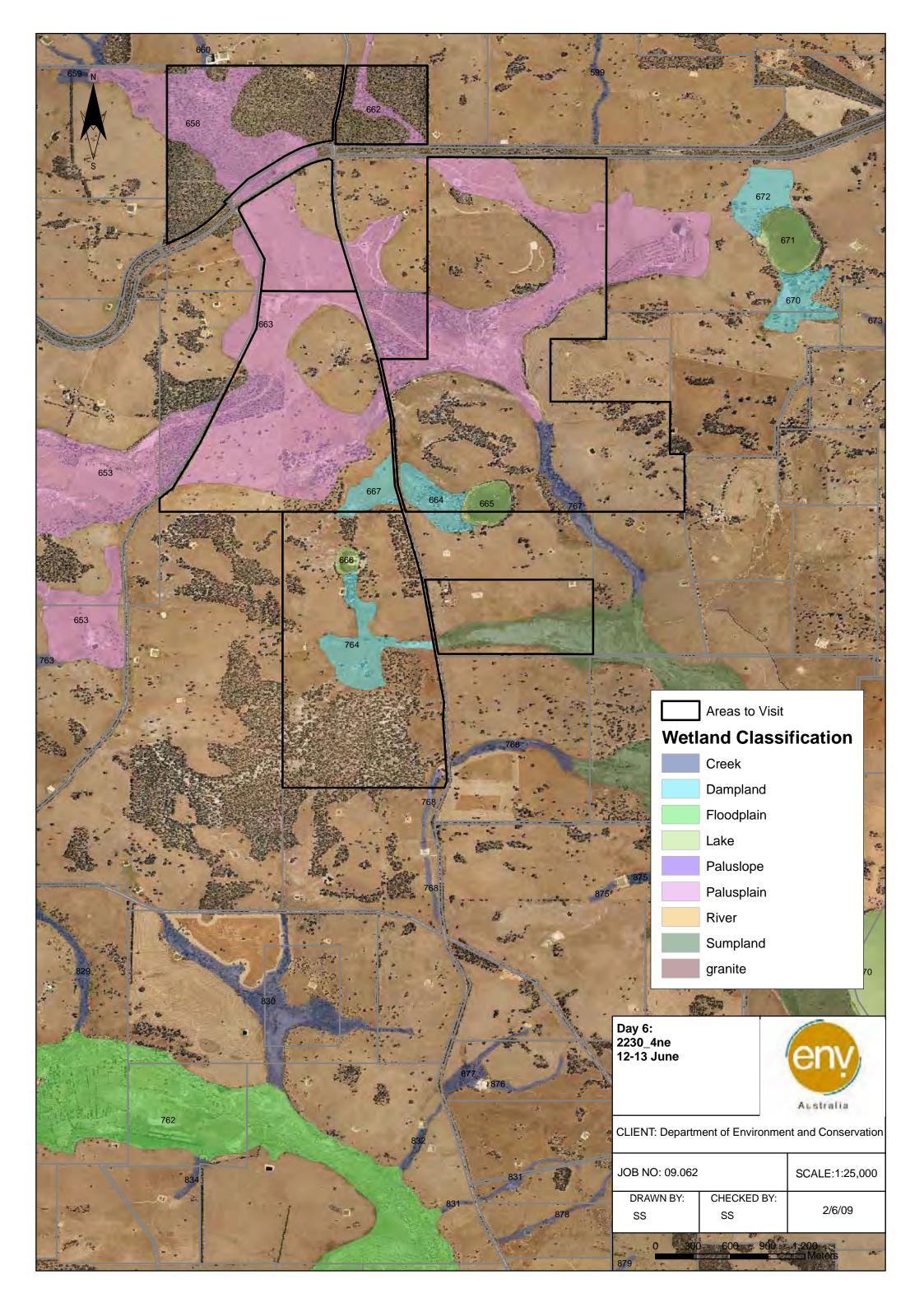


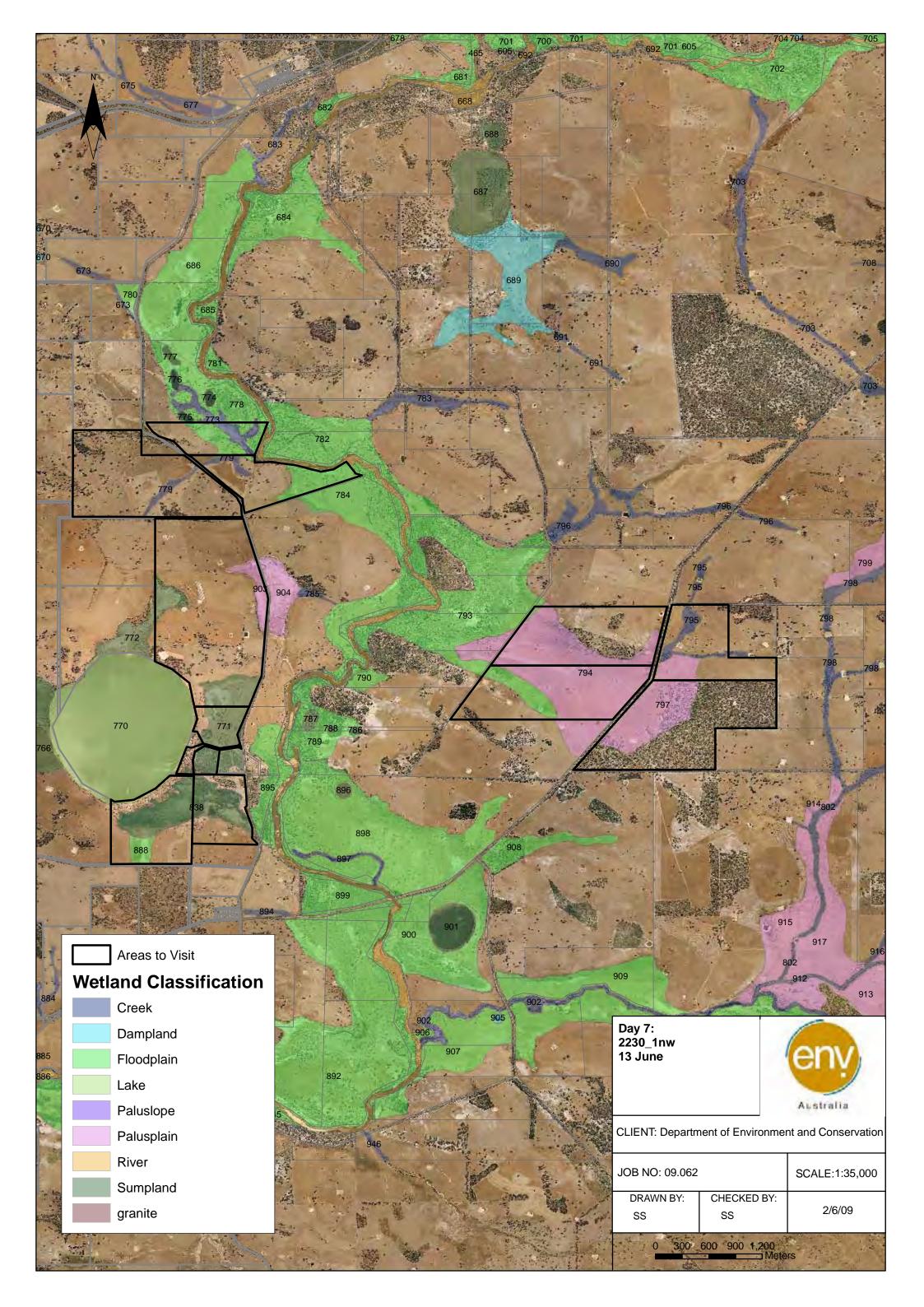


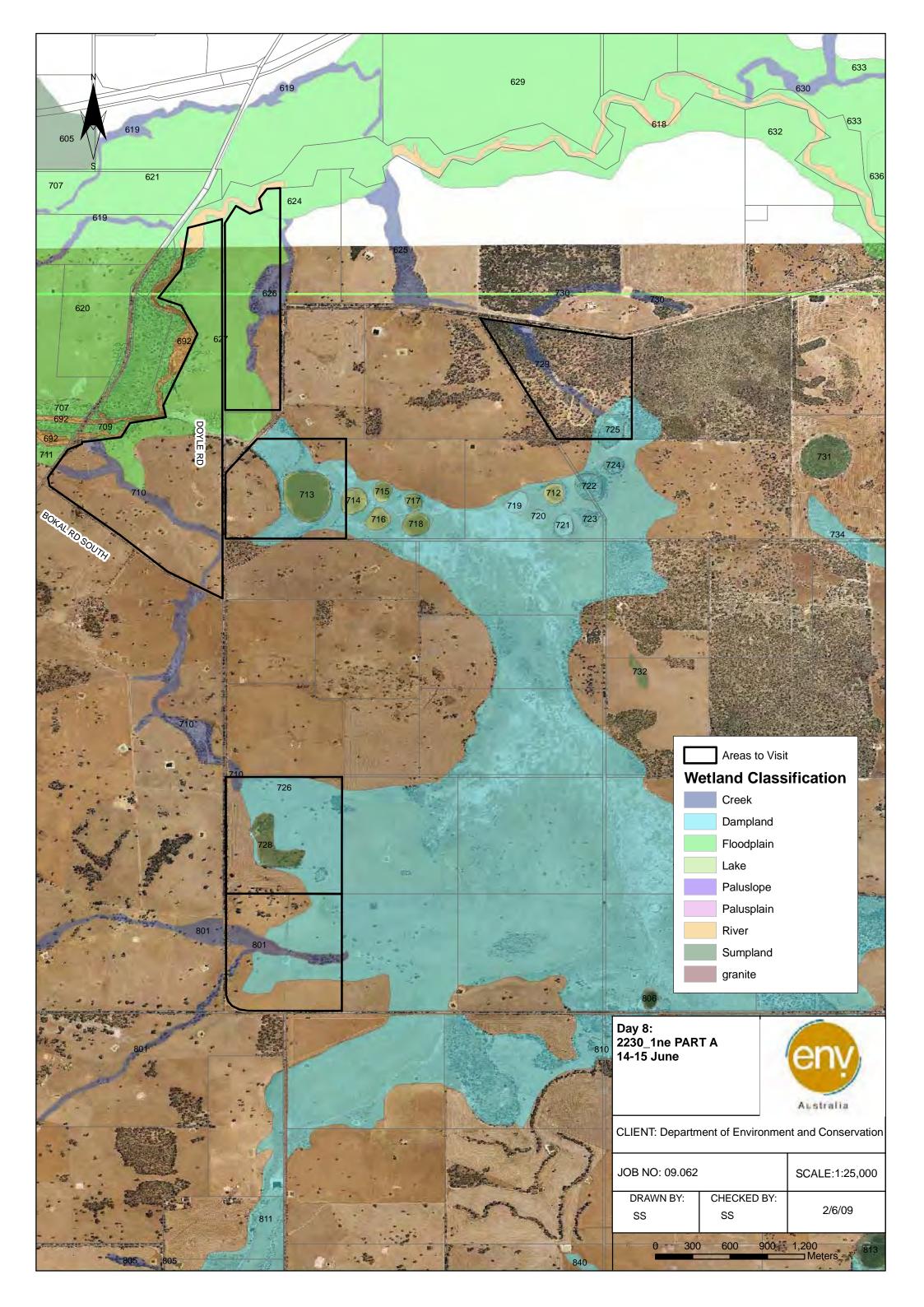


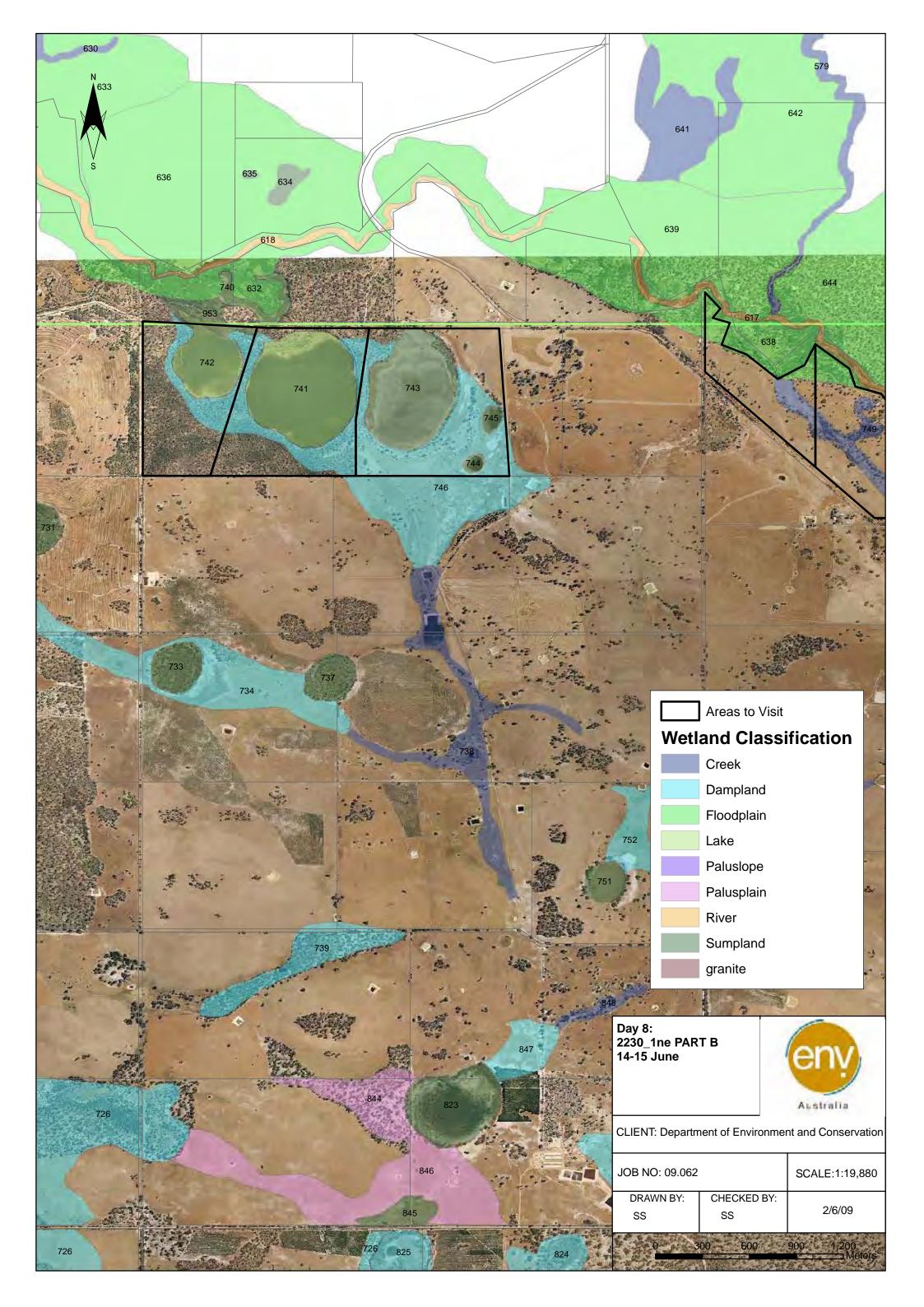












## APPENDIX B FIELD NOTES



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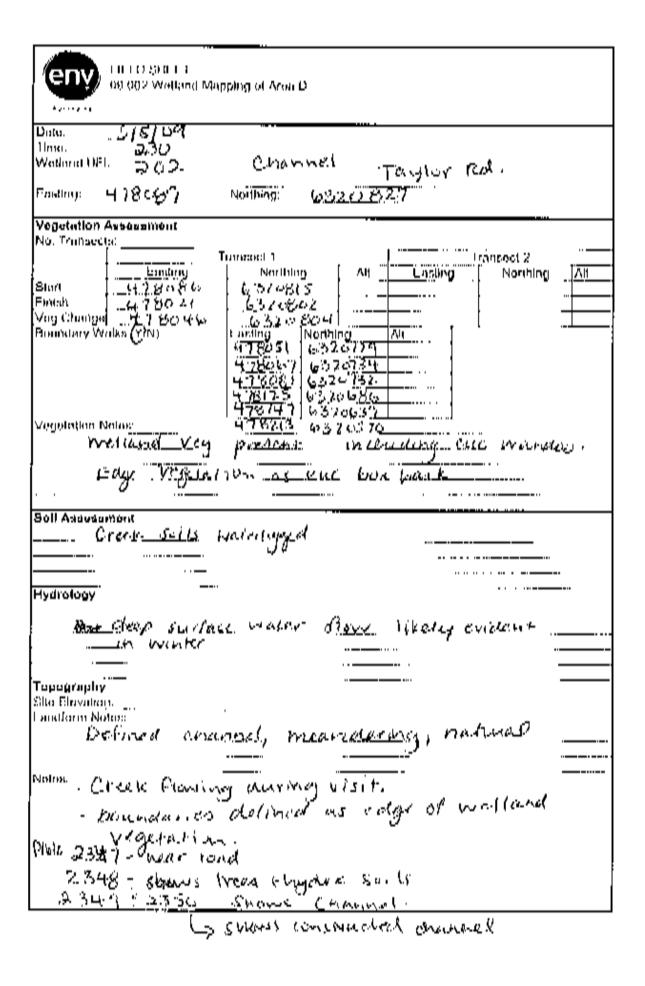
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HELD SHEET 00.002 Wathed Mapping of Area D Date: 0/5/07 Time: .... 1230 Wolland UL 1: 196 - near kneeding Poul Northlog. 6220450 47<u>9931</u> Footing: Vegetation Assessment No fransacts transoct 1 Northing Lapting All Easting Northing. Alt 1323 479431 Start . ..... Hinish 479947 Vog Chringol 479935 956 953. 6310431 Floundary Walks (M Losting Northing м 256.... 477850 6520794 479847 6320203 479851 6320813 45.7.... 0317 ... \_.... Vegetation Notes: Vegetation consists of nortaleuce initiation, acaria cuean pouridary between writiand and upland ..... Soil Аванкальной Evidence of hydric suits **.** ....... Hydrology Scouring from water "vident. Erncence Topography 5110 Lievation: 215 3 - 257 Norm Notos: Clear sumptand Brondloom Landform Notay: . . .. .... .. . .. . .. Notes: Wetland & bundling based on sul , regetation and (anotherm. Photos. 2334 made welland 2336 - encalque 2335 boundary

DELD SHEET 09.062 Walland Mapping of Acad D
Date: 5/5/03 Date: 7230 Wollond U.F. 246 Northly Meeking Pool, Ringing veg. Evening: 47931 Northly: 6320450
Vegatifier     Transacting     Transacting       Northing     Alt     Easting       Start     H199.0.31     6.32.0.587       Finish     480.1442     6.32.0.587       Vog Changel     480.1442     6.32.0.587       Poundary Wolks (Y/N)     Easting     Northing
Soil ARNORALIZATION Soils not exident -
Hydrology
Montride Some areas appear at movingh 

FIDED SHEET 09.062 Wotland Mapping of Aron D Date: 51-10-2 Thurst <u>icos</u>\_\_\_ Merking Pool - LAKE Wettern DEL 244 Northdag. Lasting: Vegetation Assossment No. Transactic 4 Transient 1 Iransom 2 Northing All <u>Northing</u> All <u>0.320</u>(23) <u>0.320</u>(23) <u>0.320</u>(25) <u>0.320</u>(25) <u>0.320</u> <u>0.3200</u> <u>0.3200</u> <u>0.3200</u> Encling i natiroj Norming IΛI 479782 6320878 25 479768 6320861 255 479768 6320861 255 479782 479943 254 Silari Houndary Walks (JVN) t healacts Eacting 1179825 6320822 Λlι Easting -2*5*24 ... 6320824 20.5 Vegetation Notes: Not much vegetation present Some trectorie Hear cages Acade bordering Soil Assussment Evidence of hydric solu at surface, durk colucy Hydrology No surface water at present but all derial project show water the ater clearing your Lopouraphy. Ole Plevation 255 Landform Notor: . Clear kasin landform \_. . \_ Welland boundary based on soils purdance of water ligging and land Purn. Notost Protos: 2341 - lase convert 2342 - mand menor



HELD SHEET 09.062 Welloud Mopping of Aron D Dota: .5/5/04 Omo: చ∹ం ..\_ Wothind UFI: 242 Facting: Nruthing: **\_**. . Vegetation Assessment No. Transloots: T(uncaset 1 Lummond 2 Easting\_ Northing Alt Finding AII. Northing Start <u>47864/</u> Finish Vog Chango <u>472622</u>2 Boundary Walka (Y/N)  $\overline{G}$   $(\gamma)$  SO257 . . . . กับปฏ ]Northing, AIL 477474 6319724 4119443 6319700 6319690 477908 477968 77813 6314638 Vegetation Notes: Vey change at dense holdaleaccort. Upland chargenbia on high one Soll Assessment <u>Arton to a depth</u> of Socan, history at dark terente annaly suggestly mast New charge paint Suil Branges\_ lawn ar Hydrology Some anderes of wateringging, not innervation Dempland .... Topography Sho Elevation: 3356 Londform Noton: Basis arm on the landscope Notos: Baundary determined by upg extent. 1 19. P ۰.

PIELO SHEET 00.062 Wetland Mapping of Area D Date: 515 Friday: Wolland UFI: ઝપઝ Freedory) Northnice Vegetation Assessment traceworking No. Transacts: - Odlercov Ironson 2 Transact I Ali Easting .... Northing Northing Casting Λlı Stort . . . . . . . . . ...**..** .. Finish ..... . .. . . . . . Veg Change] ... .. Boundary Walks (WN) Northing Enature A 412686 631 842 9 7 4974 6 319863 1177112 6 21999 319863 <del>47726</del>5 63199-58 YT. 12:68. 634 002 Vegotation Notes. Fringing regention of box box & euc (Longpros . Soil Assessment m margaded doily CREWE ... Condance \_ . . . ...... .... . ..... ...... Hydrology Endence of ponding in centre of methand **\_**..... Topography Site Elevation: Lanotorm Notes: Clear undformally pe of basin, driving regulation. Notice 2354 - pricture of medlemel

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		472796 63	121.38	257		
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Date: Time: Wetland UF	9/6/09					-
Easting:	474846	Northing: 630	8151			
	Assessment					
No. Transe	cts:	Tennenet 4		1	Francisk O	
	Easting	Transect 1 Northing Alt		Easting	ransect 2 Northing	Alt
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Date: <u>1/6/07</u> Time: 200							
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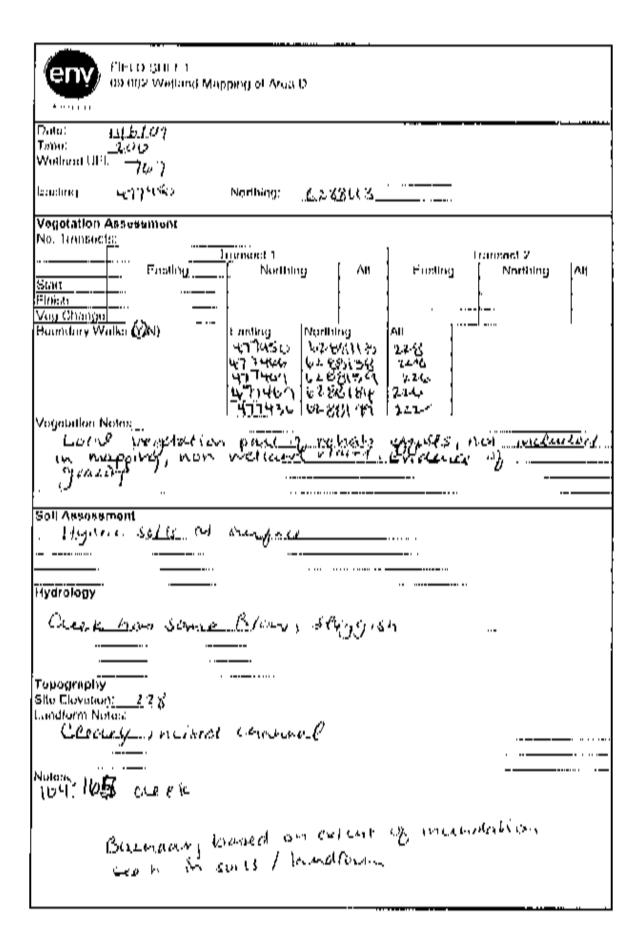
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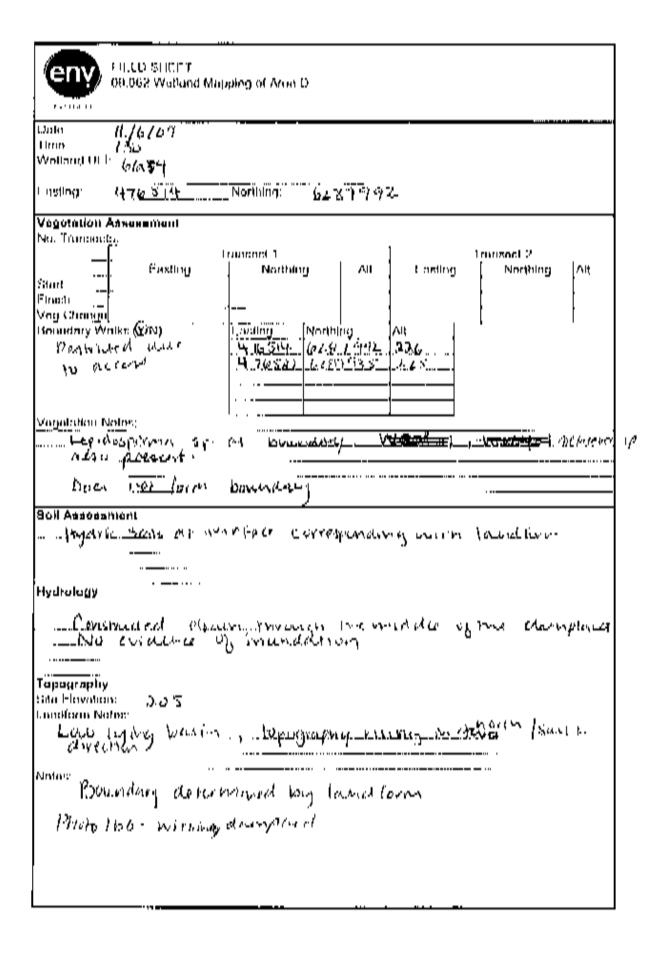
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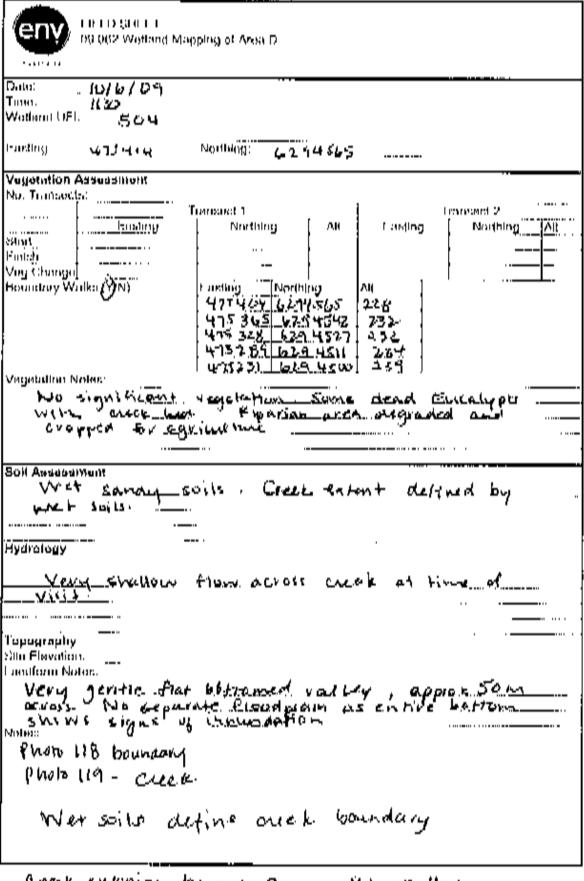
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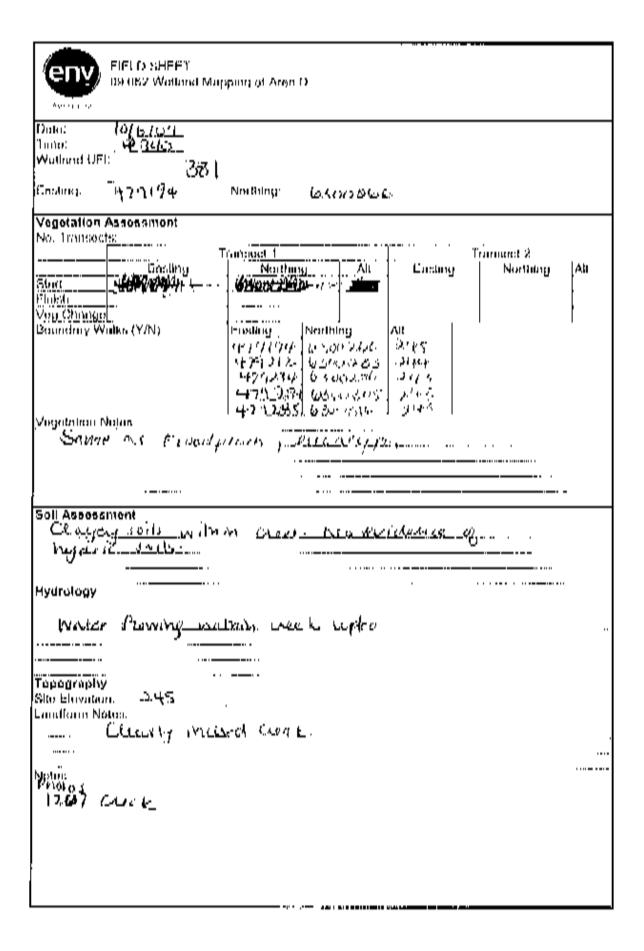


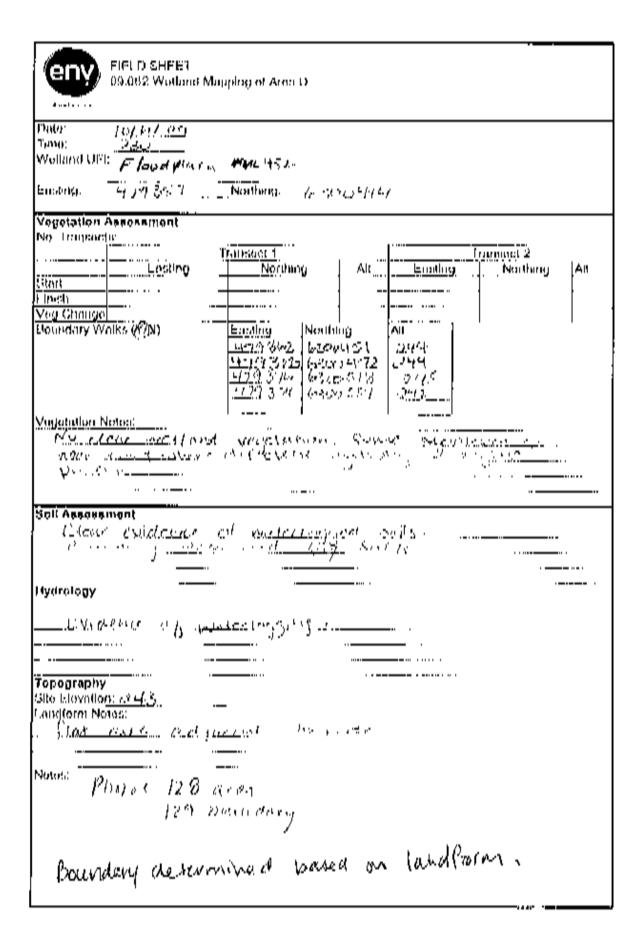
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FIELD SHEET 00.062 Wetland Mapping of Aron D
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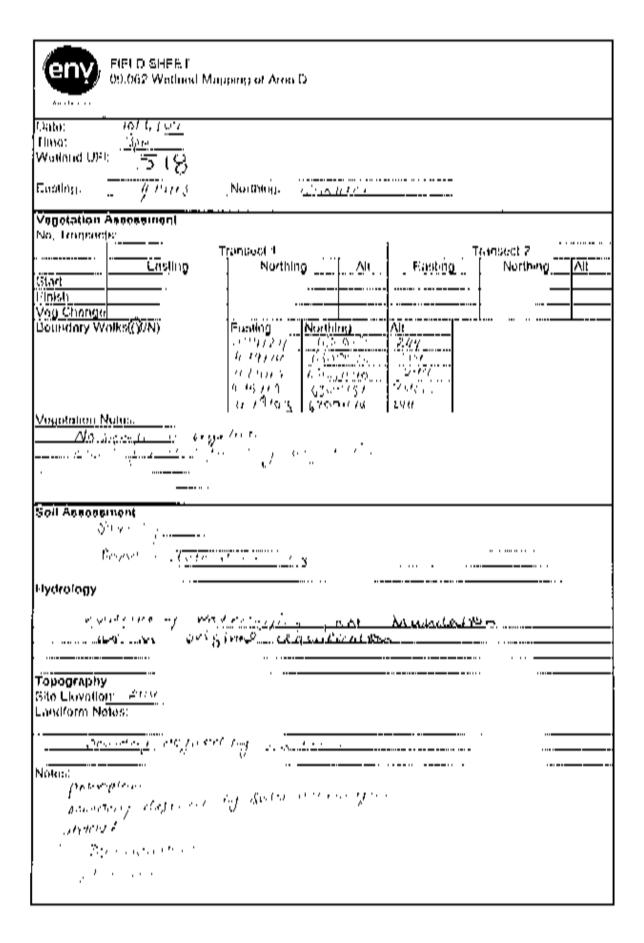




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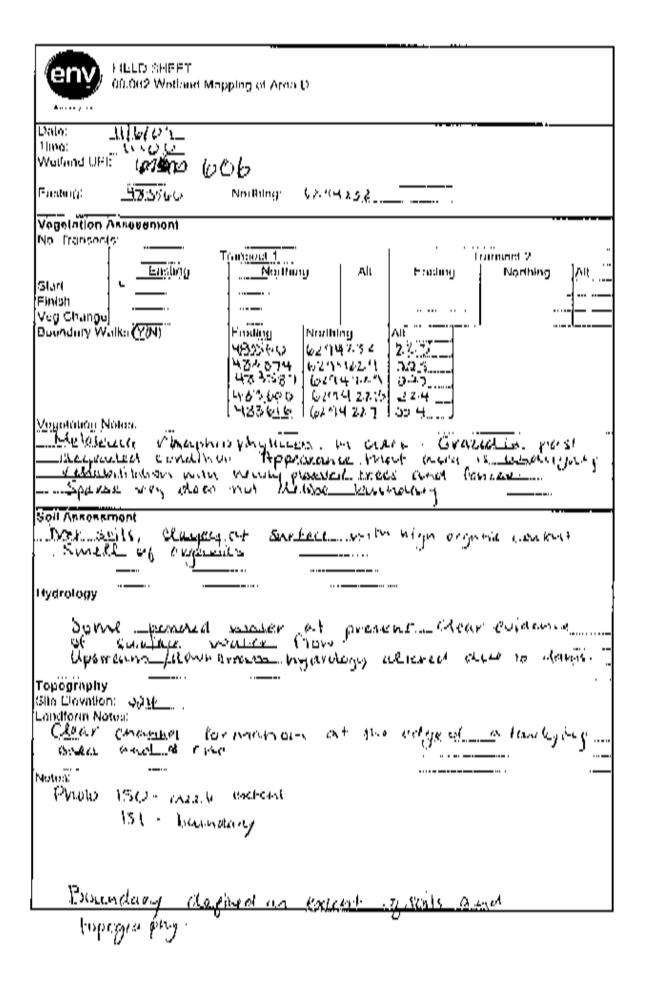
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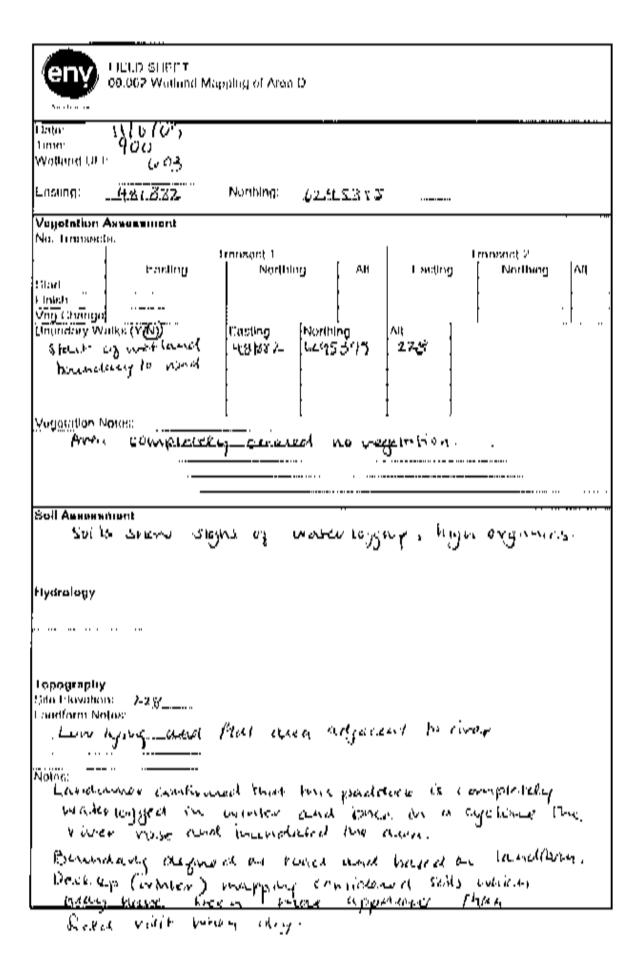
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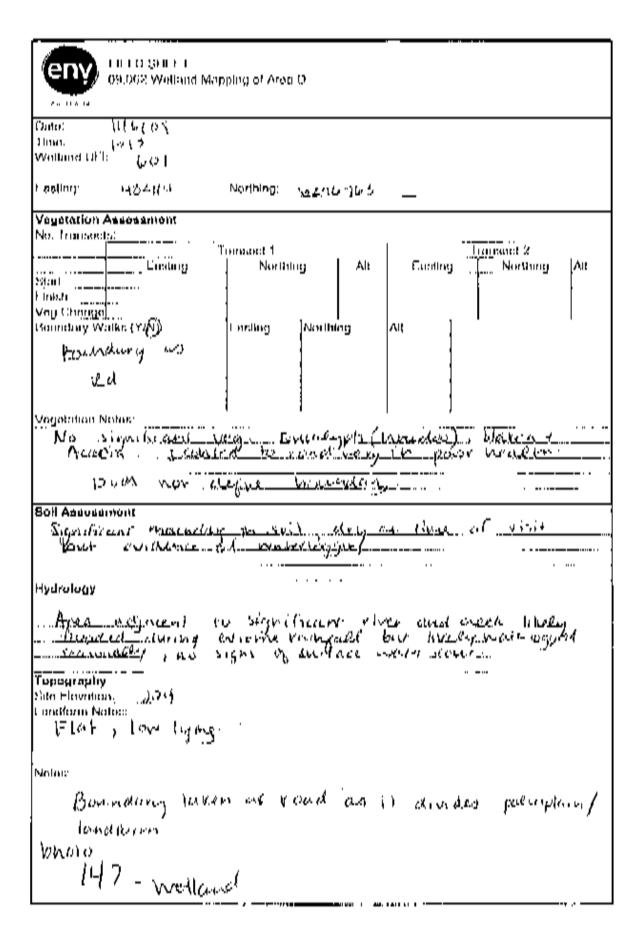
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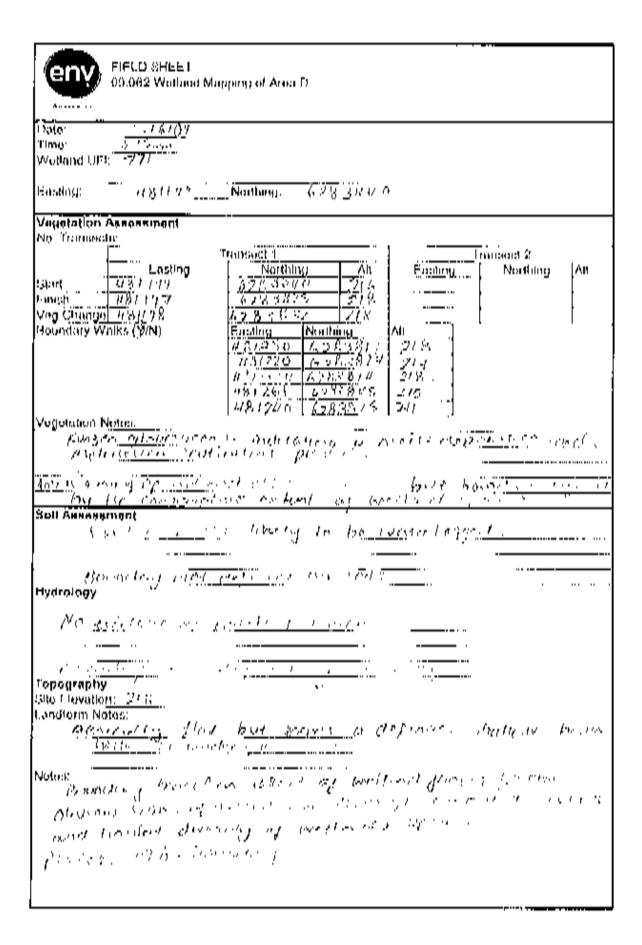
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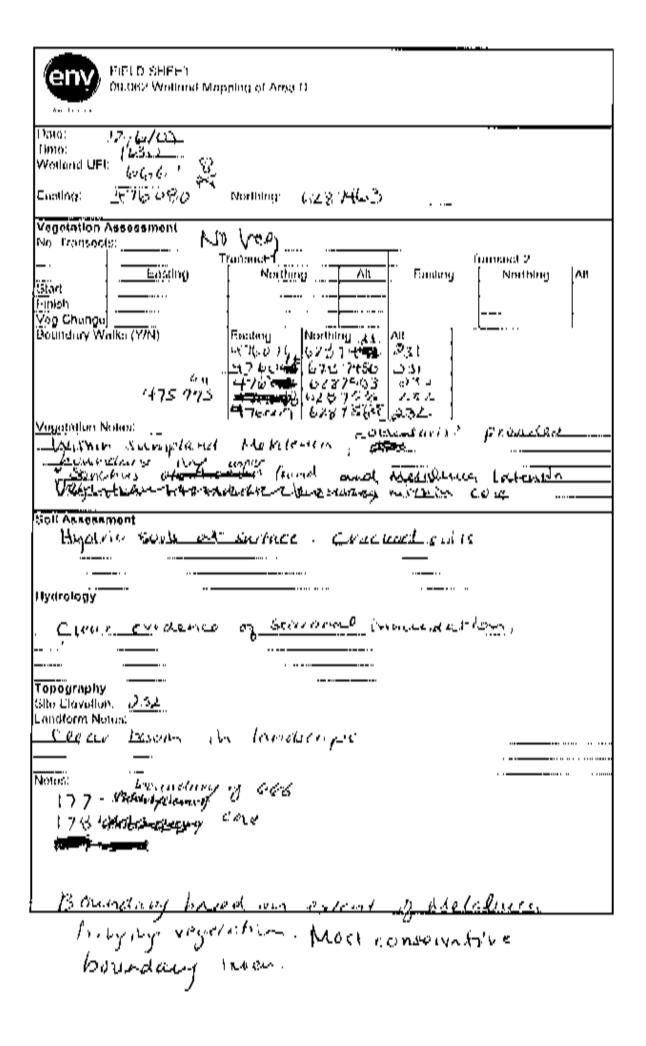
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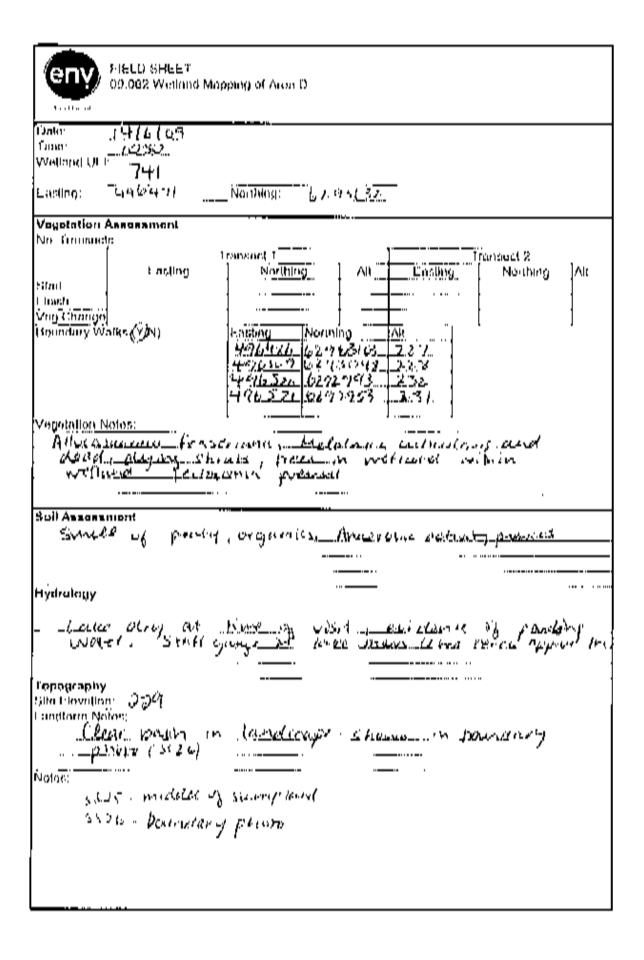
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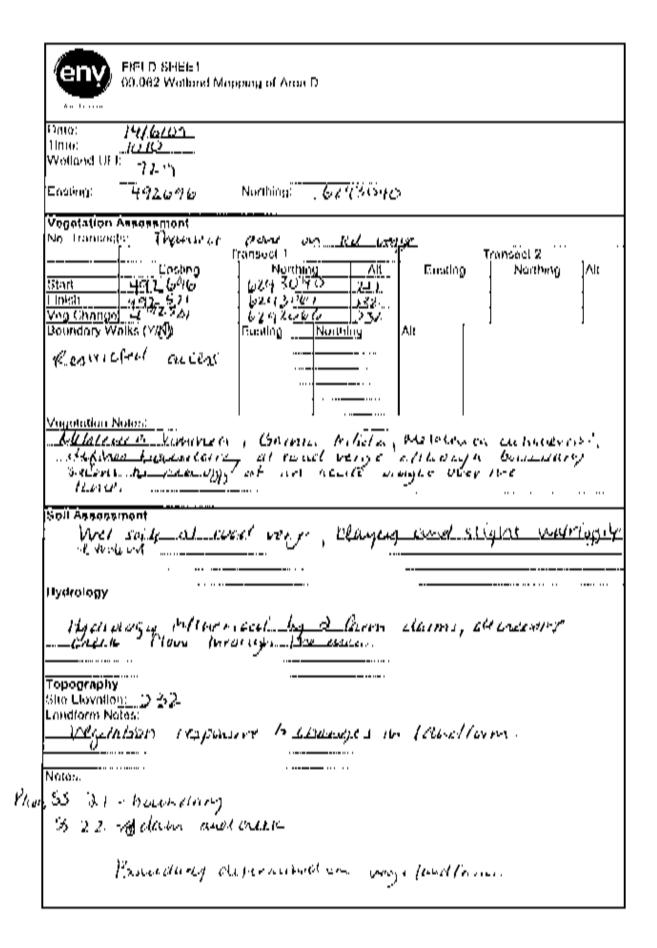


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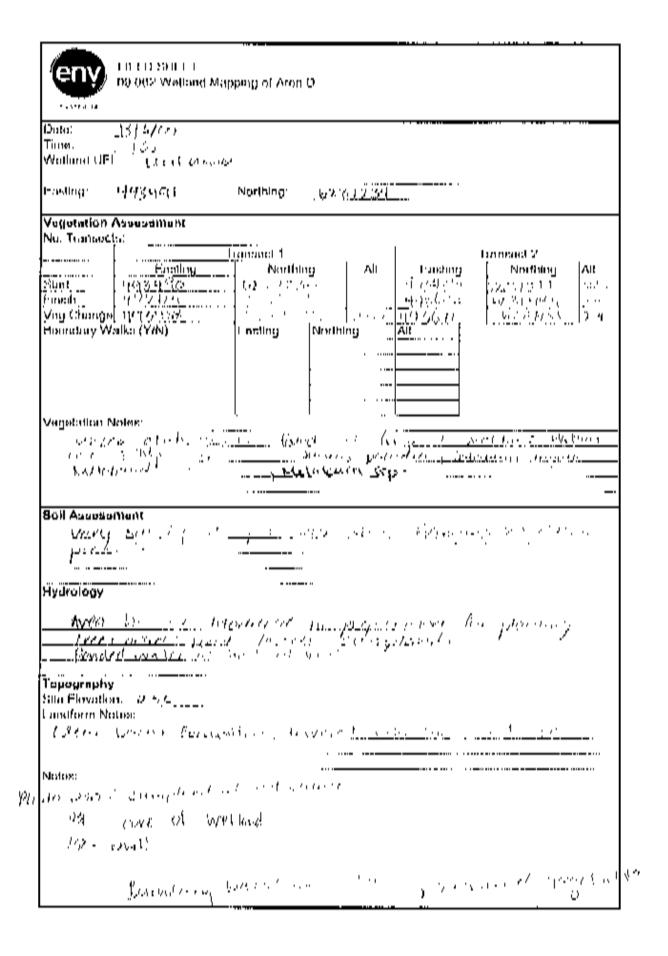
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# APPENDIX C PHOTO INDEX



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32         166         Wetland           33         166         Gentle rise           34         166         Evidence of inundation           35         166         River boundary           36         166         Pasture boundary           37         165         Boundary photo           38         165         Vegetation           39         165         Soils           40         165         Boundary           41         165         Creek bed           42         165         Boundary           43         319         44           44         319         45           44         319         46         319           44         319         46         319           44         319         46         319           44         319         5000000000000000000000000000000000000	31	166	
33         166         Gentle rise           34         166         Evidence of inundation           35         166         River boundary           36         166         Pasture boundary           37         165         Boundary photo           38         165         Vegetation           39         165         Soils           40         165         Boundary           41         165         Boundary           43         319         44           44         319         46           47         319         Ponding water           48         369         Dam			
34         166         Evidence of inundation           35         166         River boundary           36         166         Pasture boundary           37         165         Boundary photo           38         165         Vegetation           39         165         Soils           40         165         Boundary           41         165         Creek bed           42         165         Boundary           43         319         44           44         319         46           47         319         Ponding water           48         369         Dam			
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43     319       44     319       45     319       46     319       47     319       48     369	41	165	Creek bed
43     319       44     319       45     319       46     319       47     319       48     369	42	165	Boundary
44     319       45     319       46     319       47     319       48     369	43	319	
45         319           46         319           47         319           48         369	44		
46         319           47         319           48         369   Dam	45		
47         319         Ponding water           48         369         Dam			
48 369 Dam			Ponding water
49   369   Boundary between upland/	49	369	Boundary between upland/
wetland			



51         369         Slope           52         369         Juncus pallidus           53         369         Pooling water near dam           54         370         Hydric soils           55         320         Wetland           56         320         Wetland           56         320         Wetland           56         320         Wetland           57         375         Creek           58         375         Pooling water           59         341         Creek           60         341         Water ponding           61         852         Wetland           62         342         Creek           63         342         Dam           64         314         Creek           65         314         Creek           66         314         Boundary           67         316         Shows channel           69         316         Shows channel           70         316         Shows channel           71         323         Creek           73         323         Creek           74         323	50	369	Slope
52         369         Juncus pallidus           53         369         Pooling water near dam           54         370         Hydric soils           55         320         Wetland           56         320         Wetland           57         375         Creek           58         375         Pooling water           59         341         Creek           60         341         Water ponding           61         852         Wetland           62         342         Dam           64         314         Creek           65         314         Creek           66         314         Boundary           67         314         Channel form           68         316         Shows channel           69         316         Shows channel           70         316         Shows channel           71         323         Creek           72         323         Creek           73         323         Creek           74         323         Boundary           75         324         Soil           76         324<			
53         369         Pooling water near dam           54         370         Hydric soils           55         320         Wetland           56         320         Wetland           57         375         Creek           58         375         Pooling water           59         341         Creek           60         341         Water ponding           61         852         Wetland           62         342         Creek           63         342         Dam           64         314         Ronek           65         314         Creek           66         314         Boundary           67         314         Ronnel form           68         316         Shows channel           70         316         Shows channel           71         323         Creek           73         323         Creek           74         323         Boundary           75         324         Show seatern side           77         324         Shows eastern side           77         324         Show seastern side           78 </td <td></td> <td></td> <td></td>			
54         370         Hydric soils           55         320         Wetland           56         320         Wetland           57         375         Creek           58         375         Pooling water           59         341         Creek           60         341         Water ponding           61         852         Wetland           62         342         Dam           64         314         Creek           65         314         Creek           66         314         Boundary           67         314         Channel form           68         316         Shows channel           70         316         Shows soils layers           71         323         Creek           73         323         Creek           74         323         Creek           75         324         Soil           76         224         Area along west side           77         324         Show seastern side           78         327         Wetland           80         327         Wetland           81         327 </td <td></td> <td></td> <td></td>			
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103335Wetland showing rising topography in background			
			Wetland showing rising
	104	591	Creek at boundary



106         591         Creek undergoing modifications           107         591         Creek undergoing modifications           108         504         Wetland           109         504         Wetland           110         504         Wetland           111         506         Wetland form a distance           112         506         Wetland           113         506         Shows wetland and soils           114         502         Shows Creek           115         500         Floodplain           116         500         Creekline           117         500         Boundary           118         504         Boundary           119         504         Creek           120         588         Surrounding floodplain           121         588         Ponded water           122         588         Boundary           123         453         Shows sloping           124         453         Wetland           125         519         Boundary           126         519         Boundary           131         540         132           132 <t< th=""><th>105</th><th>591 Creek at bo</th><th>oundary</th></t<>	105	591 Creek at bo	oundary
modifications           107         591           Creek undergoing modifications           108         504           109         504           110         504           110         504           111         506           112         506           113         506           114         502           500         Floodplain           115         500           500         Creek           116         500           117         500           504         Boundary           118         504           117         500           500         Floodplain           117         500           501         Boundary           118         504           120         588           58         Surrounding floodplain           121         588           122         588           123         453           124         453           125         519           519         Boundary           126         519           128         452 <td></td> <td></td> <td></td>			
107         591         Creek undergoing modifications           108         504         Wetland           109         504         Wetland           110         504         Wetland           111         506         Wetland from a distance           112         506         Wetland from a distance           113         506         Shows wetland and soils           114         502         Shows vetland and soils           115         500         Floodplain           116         500         Creekline           117         500         Boundary           118         504         Boundary           119         504         Creek           120         588         Boundary           121         588         Boundary           122         588         Boundary           123         453         Shows sloping           124         453         Wetland           125         519         Wetland           126         519         Boundary           131         540         132           132         451         Extent of Floodplain           133 <td< td=""><td></td><td></td><td></td></td<>			
modifications           108         504           109         504           110         504           111         506           112         506           113         506           114         502           500         Floodplain           115         500           116         500           117         500           504         Boundary           118         504           117         500           118         504           119         504           120         588           588         Ponded water           122         588           123         453           124         453           453         Shows sloing           124         452           128         452           129         452           128         452           129         452           130         540           131         540           132         451           133         451           144         548	107		
108         504         Wetland           109         504         Wetland           110         504         Wetland from a distance           111         506         Wetland from a distance           1112         506         Wetland           113         506         Shows wetland and soils           114         502         Shows Creek           115         500         Floodplain           116         500         Creekline           117         500         Boundary           118         504         Boundary           119         504         Creek           120         588         Surrounding floodplain           121         588         Boundary           123         453         Shows sloping           124         453         Wetland           125         519         Wetland           126         519         Boundary           127         381         Creek           128         452         Boundary           130         540         131           131         540         131           132         451         Extent of Floodpl	107		
109         504         Wetland           110         504         Wetland           111         506         Wetland from a distance           112         506         Wetland           113         506         Shows wetland and soils           114         502         Shows Creek           115         500         Floodplain           116         500         Creekline           117         500         Boundary           118         504         Boundary           119         504         Creek           120         588         Surrounding floodplain           121         588         Boundary           123         453         Shows sloping           124         453         Wetland           125         519         Wetland           126         519         Boundary           127         381         Creek           128         452         Floodplain           130         540         Indary           131         540         Indary           132         451         Extent of Floodplain           133         451         Extent of Flo	108		10
110         504         Wetland           111         506         Wetland from a distance           112         506         Wetland           113         506         Shows wetland and soils           114         502         Shows Creek           115         500         Floodplain           116         500         Creekline           117         500         Boundary           118         504         Boundary           119         504         Creek           120         588         Surrounding floodplain           121         588         Boundary           123         463         Shows sloping           124         463         Wetland           125         519         Wetland           126         519         Boundary           127         381         Creek           128         452         Floodplain           129         452         Boundary           130         540         131           131         540         132           133         451         Extent of Floodplain           133         518         Area <td>100</td> <td></td> <td></td>	100		
111         506         Wetland from a distance           112         506         Wetland           113         506         Shows wetland and soils           114         502         Shows creek           115         500         Floodplain           116         500         Creekline           117         500         Boundary           118         504         Boundary           119         504         Creek           120         588         Surrounding floodplain           121         588         Boundary           122         588         Boundary           123         453         Shows sloping           124         453         Wetland           125         519         Wetland           126         519         Boundary           127         381         Creek           128         452         Boundary           130         540         131           131         540         132           133         451         Extent of Floodplain           134         518         Boundary           135         518         Area	109	504 Wetland	
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115         500         Floodplain           116         500         Creekline           117         500         Boundary           118         504         Boundary           119         504         Creek           120         588         Surrounding floodplain           121         588         Boundary           122         588         Boundary           123         453         Shows sloping           124         453         Wetland           125         519         Boundary           126         519         Boundary           127         381         Creek           128         452         Floodplain           129         452         Boundary           130         540         131           133         451         Extent of Floodplain           133         451         Extent of Floodplain           133         451         Extent of Floodplain           134         518         Area           136         443         Creek           137         443         Boundary           138         600         Shows wetland <td></td> <td></td> <td></td>			
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120         588         Surrounding floodplain           121         588         Ponded water           122         588         Boundary           123         453         Shows sloping           124         453         Wetland           125         519         Wetland           126         519         Boundary           127         381         Creek           128         452         Floodplain           129         453         Boundary           130         540         131           131         540         133           132         451         Extent of Floodplain           133         451         Extent of Floodplain           133         451         Extent of Floodplain           134         518         Boundary           135         518         Area           136         443         Creek           137         443         Boundary           138         600         Shows wetland           140         600         Shows wetland           142         602         Palusplain           143         602         Boundary			
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122         588         Boundary           123         453         Shows sloping           124         453         Wetland           125         519         Wetland           126         519         Boundary           127         381         Creek           128         452         Floodplain           129         452         Boundary           130         540         131           131         540         132           133         451         Extent of Floodplain           133         451         Extent of Floodplain           134         518         Boundary           135         518         Area           136         443         Creek           137         443         Boundary           138         600         Shows wetland           140         600         Shows wetland           142         602         Palusplain           143         602         Boundary           144         545         443           145         545         Boundary           144         545         545           145			
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124         453         Wetland           125         519         Wetland           126         519         Boundary           127         381         Creek           128         452         Floodplain           129         452         Boundary           130         540         131           131         540         133           132         451         Extent of Floodplain           133         451         Extent of Floodplain           133         451         Extent of Floodplain           134         518         Boundary           135         518         Area           136         443         Creek           137         443         Boundary           138         600         Shows wetland           140         602         Palusplain           142         602         Palusplain           143         602         Boundary           144         545         545           145         545         Boundary           146         543         147           146         543         147           148			
125         519         Wetland           126         519         Boundary           127         381         Creek           128         452         Floodplain           129         452         Boundary           130         540         131           131         540         132           133         451         Extent of Floodplain           133         451         Extent of Floodplain           133         451         Extent of Floodplain           134         518         Boundary           135         518         Area           136         443         Creek           137         443         Boundary           138         600         Shows wetland           139         600         Shows wetland           140         602         Palusplain           143         602         Boundary           144         545         145           145         545         Boundary           146         543         147           148         552         Boundary           148         552         Boundary           148			ang
126         519         Boundary           127         381         Creek           128         452         Floodplain           129         452         Boundary           130         540			
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128         452         Floodplain           129         452         Boundary           130         540           131         540           132         451         Extent of Floodplain           133         451         Extent of Floodplain           133         451         Extent of Floodplain           133         451         Extent of Floodplain           134         518         Boundary           135         518         Area           136         443         Creek           137         443         Boundary           138         600         Shows wetland           139         600         Shows wetland           140         602         Palusplain           143         602         Boundary           144         545         145           145         545         Boundary           148         552         Boundary           148         552         Boundary           148         552         Boundary           148         552         Boundary           150         600         Creek extent           150 <td< td=""><td></td><td></td><td></td></td<>			
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131         540           132         451         Extent of Floodplain           133         451         Extent of Floodplain           134         518         Boundary           135         518         Area           136         443         Creek           137         443         Boundary           138         600         Shows wetland           139         600         Shows wetland           140         602         Palusplain           143         602         Boundary           144         545         145           145         545         Boundary           146         543         147           147         601         Wetlands           148         552         Boundary           149         552         Creek           150         600         Creek extent           151         600         Boundary           152         605         Shows wet soils           153         605         Shows wet soils		,	
132         451         Extent of Floodplain           133         451         Extent of Floodplain           134         518         Boundary           135         518         Area           136         443         Creek           137         443         Boundary           138         600         Shows wetland           139         600         Shows wetland           140         600         Shows wetland           142         602         Palusplain           143         602         Boundary           144         545         State           145         545         Boundary           144         545         State           145         545         Boundary           146         543         State           147         601         Wetlands           148         552         Boundary           149         552         Creek           150         600         Creek extent           151         600         Boundary           152         605         Shows wet soils           153         605         Shows wet soils			
133       451       Extent of Floodplain         134       518       Boundary         135       518       Area         136       443       Creek         137       443       Boundary         138       600       Shows wetland         139       600       Shows wetland         140       600       Shows wetland         142       602       Palusplain         143       602       Boundary         144       545       145         145       545       Boundary         146       543       147         147       601       Wetlands         148       552       Boundary         149       552       Creek         150       600       Creek extent         151       600       Boundary         152       605       Shows wet soils         153       605       Shows wet soils			
134         518         Boundary           135         518         Area           136         443         Creek           137         443         Boundary           138         600         Shows wetland           139         600         Shows wetland           140         600         Shows wetland           142         602         Palusplain           143         602         Boundary           143         602         Boundary           144         545         145           145         545         Boundary           146         543         147           147         601         Wetlands           148         552         Boundary           149         552         Creek           150         600         Creek extent           151         600         Boundary           152         605         Shows wet soils           153         605         Shows wet soils           154         605         Melaleuca sp. Near Quill	132		
135         518         Area           136         443         Creek           137         443         Boundary           138         600         Shows wetland           139         600         Shows wetland           140         600         Shows wetland           142         602         Palusplain           143         602         Boundary           144         545         545           145         545         Boundary           146         543         147           147         601         Wetlands           148         552         Boundary           149         552         Creek           150         600         Creek extent           151         600         Boundary           152         605         Shows wet soils           153         605         Shows wet soils           154         605         Melaleuca sp. Near Quill	133	451 Extent of Fl	oodplain
136         443         Creek           137         443         Boundary           138         600         Shows wetland           139         600         Shows wetland           140         600         Shows wetland           142         602         Palusplain           143         602         Boundary           144         545            145         545         Boundary           146         543            147         601         Wetlands           148         552         Boundary           149         552         Creek           150         600         Creek extent           151         600         Boundary           152         605         Shows wet soils           153         605         Shows wet soils	134	518 Boundary	
136         443         Creek           137         443         Boundary           138         600         Shows wetland           139         600         Shows wetland           140         600         Shows wetland           142         602         Palusplain           143         602         Boundary           144         545            145         545         Boundary           146         543            147         601         Wetlands           148         552         Boundary           149         552         Creek           150         600         Creek extent           151         600         Boundary           152         605         Shows wet soils           153         605         Shows wet soils	135	518 Area	
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138         600         Shows wetland           139         600         Shows wetland           140         600         Shows wetland           142         602         Palusplain           143         602         Boundary           144         545         145           145         545         Boundary           146         543         147           148         552         Boundary           149         552         Creek           150         600         Creek extent           151         600         Boundary           152         605         Shows wet soils           153         605         Melaleuca sp. Near Quill	137	443 Boundary	
139         600         Shows wetland           140         600         Shows wetland           142         602         Palusplain           143         602         Boundary           144         545         145           145         545         Boundary           146         543         147           148         552         Boundary           149         552         Creek           150         600         Creek extent           151         600         Boundary           152         605         Shows wet soils           153         605         Shows wet soils           154         605         Melaleuca sp. Near Quill	138		and
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142         602         Palusplain           143         602         Boundary           144         545			
143         602         Boundary           144         545	142		
144         545           145         545         Boundary           146         543           147         601         Wetlands           148         552         Boundary           149         552         Creek           150         600         Creek extent           151         600         Boundary           152         605         Shows wet soils           153         605         Shows wet soils           154         605         Melaleuca sp. Near Quill			
145         545         Boundary           146         543           147         601         Wetlands           148         552         Boundary           149         552         Creek           150         600         Creek extent           151         600         Boundary           152         605         Shows wet soils           153         605         Shows wet soils           154         605         Melaleuca sp. Near Quill		,	
146         543           147         601         Wetlands           148         552         Boundary           149         552         Creek           150         600         Creek extent           151         600         Boundary           152         605         Shows wet soils           153         605         Shows wet soils           154         605         Melaleuca sp. Near Quill			
147         601         Wetlands           148         552         Boundary           149         552         Creek           150         600         Creek extent           151         600         Boundary           152         605         Shows wet soils           153         605         Shows wet soils           154         605         Melaleuca sp. Near Quill			
148         552         Boundary           149         552         Creek           150         600         Creek extent           151         600         Boundary           152         605         Shows wet soils           153         605         Shows wet soils           154         605         Melaleuca sp. Near Quill			
149         552         Creek           150         600         Creek extent           151         600         Boundary           152         605         Shows wet soils           153         605         Shows wet soils           154         605         Melaleuca sp. Near Quill			
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153605Shows wet soils154605Melaleuca sp. Near Quill			il -
154 605 <i>Melaleuca</i> sp. Near Quill			
	154	605   <i>Melaleuca</i> s   Road	sp. Near Quill



155	613	Shows Emu Swamp
155	613	Boundary
157	614	Shows creek
158	663	
159	663	
160	664	Within dampland
161	665	Wetland
162	665	Boundary
163	665	From core of wetland
164	767	Creek
165	767	Creek
166	658	Wetland
167	658	Boundary
168	658	Lepidosperma sp.
169	661	
170	662	Lepidosperma sp.
171	662	
172	667	Shows Dampland
173	667	Shows Dampland
174	766	Boundary
175	766	Sumpland
175		
	766	Channel within sumpland
177	666	Boundary
178	666	Core
179	764	Core
181	770	UFI 770 in background
182	629	Shows rail and road
183	629	Boundary
184	629	Boundary
185	629	Melaleuca species
186	565	Creek
187	565	
188	628	Remnant vegetation (south) and paddock (north) possibly historically connected
189	628	Looking south into
		remnant vegetation
190	566	<u> </u>
191	491	Creek
192	491	Channel
193	574	Channel
195	838	Wetland
196	838	
197	838	Boundary
198	771	Boundary
199	903	Looking across dampland
202	780	Wetland
203	673	Wetland
204	686	Sign showing control
		program undertaken for
		surface water salinity



007	A ~ ~	
205	686	Wetland
206	686	Scoured Area
207	779	Culverts under Rd
208	779	Channel
209	772	Sumpland
210	772	Boundary
213	678	Wetland
214	678	Boundary
215	795	Wetland
216	795	Does not show signs of
		wetland
217	793	Culvert under road
218	793	Channel
219	793	Melaleuca and Sheoak
220	793	Lepidosperma sp.
221	796	Creek
222	796	Culvert
223	790	Taken from road
245	790	Palusplain
245	799 799	
		Lepidosperma sp.
226	805	
227	810	High water table in
		excavation
228	810	East of Bokal Rd South
229	811	West of Bokal Rd South
230	UNK	
231		Core of wetland
232	UNK	
233	806	Sumpland
234	801	
235	801	
2334	196	Inside wetland
2335	196	Boundary
2338	246	End of transect
2339	246	Start of transect
2341		Lake centre
2342		Lake edge
2343		Vegetation change
2344	244	Upland Acacia sp.
2347	202	Near road
2348	202	Shows trees and hydric
2040	202	soils
2349	202	Shows channel
2350	202	Shows constructed
0054	0.40	channel Disture of wotland
2354	243	Picture of wetland
2357	3	Channel
2358	3	Soil photo
2361	174	
2362	174	Edge of area
2363	194	Adjacent paddock
SS7	710	
SS8	710	



SS9	710	
SS10	627	Hillman River (UFI 692)
		fringe
SS11	627	Boundary in paddock
SS12	709	River boundary
SS13	709	Floodplain
SS14	709	Mixed vegetation (Upland
		and Wetlands species)
SS15	692	
SS16	726	Shows wetland species
		and planted species
SS17	626	Spillway
SS18	626	Creek and boundary
SS19	625	Boundary
SS20	625	Core
SS21	729	Boundary
SS22	729	Dam and Creek
SS23	746	Boundary, UFI 743 in
		background. Could not
		Access.
SS24	746	Within core of wetlands,
		showing fringe
SS25	741	Middle of Sumpland
SS26	741	Boundary
SS27	742	Swamp
SS28	742	Boundary



# APPENDIX D FLORA SPECIES LIST



#### APPENDIX D

#### FLORA SPECIES LIST

\* denotes foreign introduced species

#### Abbreviations:

sp.: species (singular)	var.: variety
spp.: species (plural)	ms: manuscript name (unpublished)
subsp.: subspecies	

Source: Western Australian Herbarium (2009)

FAMILY	ТАХА		COMMON NAME	HABITAT PREFERENCE		
		IAAA		Obligate	Facultative	Dryland
TYPHACEAE	* Typha	orientalis	Bulrush	Ń		
POACEAE	* Eragrostis	curvula	African Lovegrass		$\checkmark$	
CYPERACEAE	Baumea Ficinia Gahnia	juncea nodosa trifida	Bare Twig Rush Knotted Club Rush Coastal Saw Sedge	$\sqrt{1}$		
RESTIONACEAE	Lepidosperma	?squamatum/ striatum		$\checkmark$		
JUNCACEAE	Juncus	pallidus	Pale Rush	$\checkmark$		
XANTHORRHOEACEAE	Xanthorrhoea	preissii	Grass Tree		$\checkmark$	
CASUARINACEAE	Allocasuarina Casuarina	fraseriana obesa	Sheoak Swamp Sheoak		$\checkmark$	$\checkmark$
CHENOPODIACEAE	Tecticornia	lepidosperma		$\checkmark$		
HEMEROCALLIDACEAE	Dianella	revoluta	Blueberry Lily		$\checkmark$	
MIMOSACEAE	Acacia	acuminata	Jam Wattle		$\checkmark$	
MYRTACEAE	Callistemon Corymbia Eucalyptus Eucalyptus Eucalyptus Eucalyptus Kunzea Melaleuca Melaleuca Melaleuca Melaleuca Melaleuca Melaleuca Verticordia	phoeniceus calophylla marginata rudis ssp. wandoo subsp. wandoo glabrescens cuticularis lateritia preissiana rhaphiophylla ssp. viminea subsp. viminea densiflora	Lesser Bottle Brush Marri Jarrah Flooded Gum Wandoo Spearwood Saltwater Paperbark Robin Redbreast Bush Moonah Swamp Paperbark Compacted Featherflower	~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~		V
SOLANACEAE	* Solanum	nigrum	Black Berry Nightshade	$\checkmark$		
ASTERACEAE	* Conyza * Sonchus	sp. <i>asper</i>	Rough Sowthistle	$\sqrt[]{}$		

# APPENDIX E METADATA



## APPENDIX E

## AREA D WETLAND MAPPING METADATA STATEMENT

This metadata statement is prepared to assist in interpreting the GIS layer Area D Wetlands.

#### 1. Dataset

Title: Area\_D\_Wetlands

Custodian: Department of Environment and Conservation

Jurisdiction: Western Australia

#### 2. Contact

Contact Organisation Name: Department of Environment and Conservation

Contact Organisation Jurisdiction: Western Australia

Contact Position:

Mail Address: Locked Bag 104

**Bentley Delivery Centre** 

Suburb: Bentley

Postcode: 6983

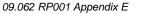
State: WA

Country: Australia

#### 3. Description

The data contained within the *Area D Wetlands* mapping layer covers wetlands within the Wheatbelt region of Western Australia predominantly within the Shire of West Arthur. The area is encompassed by the following 1:25,000 map sheets for the Middle Blackwood (Area D):

- 2231-III NE;
- 2231-III SE;
- 2230-IV NE;
- 2231-II NW;
- 2231-II SW;
- 2230-I NW;
- 2231-II NE;





- 2231-II NE; and
- 2230-I NE.

Each wetland is classified based on its geomorphic properties and is captured at a 1:25000 scale. For further information on geomorphic classification of wetlands refer to *Wetlands of the Swan Coastal Plain Volume 2* (Hill et al, 1996).

Keywords: Wetland, geomorphic wetland, West Arthur

### 4. Data Currency

Beginning Date: 22/6/09

Ending Date: Current

### 5. Dataset Status

Progress: Draft

### 6. Data Quality

Scale: Data captured at a 1:25000 scale

Positional Accuracy: + or - 21m over the dataset

Logistical Consistency: Attributed polygons

Completeness: Map sheet area as listed above

### 7. Metadata Date: 22/6/09

### 8. Details of Captured Attributes

- a. UFI: unique feature identifier for each wetland polygon
  - Field type: Integer
  - Key field, no duplicates
- **b. Class:** Geomorphic classification of wetland according to Seminiuk & Seminiuk (1995) were recognised
  - Field type: Text
  - Possible Attributes: River, Creek, Lake, Sumpland, Dampland, Palusplain, Floodplain, Paluslope



- **c. Criteria1:** Boundary criteria are provided in order of importance regarding the delineation of wetland boundaries. This field refers to the dominant criteria for boundary delineation.
  - Field Type: Text
  - Possible Attributes: V, S, L denoting vegetation, soil and landform respectively.
- **d. Criteria2:** Boundary criteria are provided in order of importance regarding the delineation of wetland boundaries. This field refers to the secondary criteria used for boundary delineation. May be null.
  - Field Type: Text
  - Possible Attributes: V, S, L denoting vegetation, soil and landform respectively. Can be a null value
- e. Criteria3: Boundary criteria are provided in order of importance regarding the delineation of wetland boundaries. This field refers to the third rated criteria for boundary delineation.
  - Field Type: Text
  - Possible Attributes: V, S, L denoting vegetation, soil and landform respectively. Can be a null value.
- f. Field Visit: Denotes whether a field visit was undertaken for the wetland
  - Field Type: Text
  - Possible Attributes: Y or N denoting yes or no.
- g. Date: Date of which field visit occurred
  - Field Type: Date

