SUMMER SCHOLARSHIP - 2006/2007 SEASON

Project title

Integrating disparate geospatial data to produce a geographic information system for the Namoi catchment

Project Number: 5.10.03.13

Aims and milestones

- To collate the disparate soil and other geospatial data for the Namoi catchment into a common location and into a single projection to develop a geographical information system (GIS) for the Namoi catchment.
- To provide this GIS to the Namoi Catchment Management Authority as part of a project to further develop the amount of soil and other landscape information available for management purposes.

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Project Summary

This project collected and collated soil and other geospatial data into a common location and projection to provide a GIS for the Namoi Catchment Management Authority (CMA) to provide information for land management within the Namoi Catchment. Soil information was successfully obtained from a number of disparate sources: individuals, government departments and research organisations or institutions. Unfortunately it was not possible to collate all known soil data for the catchment as some data were not made publicly available. The geospatial data obtained from various sources, and derived as part of this project, were successfully brought into a common projection and a GIS provided to the Namoi CMA. This GIS will be useful in planning future field work to target areas without sufficient coverage currently as well as providing a source of information for the CMA and other stakeholders in the catchment.

Background

Geospatial data, such as soil information, digital elevation, climatic, landuse and other landscape data exist in an uncoordinated and multi-formatted manner. Considering the Namoi catchment, a number of different organisations, such as the Cotton Cooperative Research Centre (CRC), NSW Department of Natural Resources, as well as educational institutions currently hold these data. The ability for researchers, land managers and planners to access such data for their various purposes is hindered by the disparate nature of this data. Collection of these disparate data into a common location and integration with a geographical information system will allow stakeholders to more readily access and use this data.

Aims and objectives

a) Collect and collate soil data and other geospatial data held by different organizations in one location.
b) Project the different data to the same coordinate system - Geocentric Datum of Australia (1994) and Map Grid of Australia (GDA 94 MGA zone 55)
c) Derive Useful terrain attributes, such as slope, aspect, topographic wetness index (TWI), multi resolution valley bottom flatness (MrVbf), curvature and aspect, required for landscape, ecological and hydrological modelling.
d) Apply the relationship of soil types with the commonly available terrain and other geospatial attributes to make a continues digital soil map covering the whole of the Namoi catchment
e) Publish the data and the Geographical Information System
f) Supply the data and GIS to the stakeholders, especially the CMA.

Methodology

Data Collection

The data types and sources are summarized in Table 1. Digital Elevation data was obtained from the NASA SRTM 90m database (http://srtm.csi.cgiar.org/). Tiles 66:19 and 67:19 were mosaicked using ArcGIS 9.1, reprojected to GDA 1994 MGA zone 55. The Namoi catchment area was then extracted using the ArcTool 9.1 “Extract by mask”.

Table 1 Data type and source for Namoi catchment landscape and soil data.

Data Type	Source
Digital Elevation Data	NASA SRTM 90m database (http://srtm.csi.cgiar.org/)
Soil Profile Data	NSW DNR, The University of Sydney, Gunnar Kirchoff
Continuous soil chemistry and physics data	The University of Sydney, Gunnar Kirchhoff
Radiometric and Magnetic Data	NSW Department of Mineral Resources
Soil Landscape Data	
Landscape Management Unit data	NSW DNR, The University of Sydney
Land Use Data	NSW DNR
Climate Data	The University of Sydney, Robert Banks (Soil Futures Consulting, Gunnedah).
NDVI (Maxwell *et al.*, 2002)	The University of Sydney

Soil information is usually stored in the form of soil point observations – profile descriptions, and soil maps either traditional or digital. Soil profile data was primarily obtained from the NSW Department of Natural Resources (DNR) – information stored in the SALIS database, and the University of Sydney – both the Cotton CRC soils database and data from research projects carried out in the Namoi catchment. Requests for soil information were put to a number of individuals, organisations and institutions however a number of researchers were unwilling to the soil data they had collected into a database over which they would not have control. Continuous soil chemistry and physical data for sections of the upper Namoi were obtained from the University of Sydney.

Radiometric and magnetic data was obtained from the NSW Department of Mineral Resources. The magnetic data was mosaicked from the GDA1994 MGA zone 55 and 56 map sheets. Radiometric data was obtained as single region maps and a mosaicked dataset for all NSW. The Namoi catchment area was extracted from the mosaicked dataset using the ArcTool 9.1 "Extract by mask". Landuse data was obtained from the NSW DNR while climate data was obtained from The University of Sydney and Robert Banks.

All data was presented with the metadata as provided by the original controlling organisation. In some cases this meant very little information regarding data quality or purpose was available. Metadata for the DEM and terrain attributes was developed to provide information on the source and accuracy of the data.

Reprojection to GDA 1994 MGA

The reprojection of the data to the common coordinate system and projection – The Geodetic Datum of Australia, 1994 Map Grid of Australia Zone 55 (GDA 1994 MGA Zone 55) was undertaken for each dataset using the following process:

1. Identify the coordinate system and projection of the original data through associated metadata
2. Define the original coordinate system and projection for the dataset within ArcGIS 9.1 if not correctly spatially referenced

3. Project the data using Project Raster or Project Feature tool in ArcGIS 9.1. The choice of tools depends on the nature of the original data – whether raster or vector data. All data is projected to GDA 1994 MGA zone 55.

Terrain Attribute Derivation

Primary Terrain Attributes

The primary terrain attributes – slope, aspect, profile curvature and plan curvature were derived using the ArcGIS 9.1 Spatial Analyst toolset. The 90m DEM for the Namoi catchment obtained from the NASA SRTM was used for these analyses.

Secondary Terrain Attributes

Topographic Wetness Index (TWI) was calculated using the CLASS Spatial Analyst (CSIRO) spatial modelling tool. The 90m DEM for the Namoi catchment obtained from the NASA SRTM was used for this analysis. The Class Spatial Analyst carries out a number of analyses to derive the Topographic wetness index including filling small depressions in the DEM, obtaining D8 flow direction and flow accumulation, D∞ flow direction and flow accumulation.

Multi resolution valley bottom flatness (MrVbf) (Gallant & Dowling, 2003) was obtained using the CLASS Spatial Analyst (CSIRO) spatial modelling tool (http://toolkit.net.au). Due to computing limitations MrVbf was derived from a 200m DEM for the Namoi Catchment obtained by projecting the NASA SRTM 90m DEM with cell size 200.

Hammond Landform Classification

Landform within the Namoi catchment was classified using the scheme developed by Hammond (1964). The classification was obtained using a modified version of Dikau *et al* (1991) processed using ArcGIS 9.1.

Digital Soil Mapping

The SCORPAN method (McBratney *et al.*, 2003) was used to create a soil map across the catchment. The covariates used were elevation, slope, aspect, MrVbf, TWI, NDVI magnetic and radiometric data, landuse, landform class. Areas without radiometric data (See Figure) were modeled using the same set of covariates minus the radiometric data.

Soil profile data from DNR and the University of Sydney with ASC suborder classification were used to create a classification tree model. ASC suborder classifications were amalgamated to form 30 abridged classes (see table).

- Covariate layers were sampled using ArcGIS Spatial Analyst Sample tool – Bilinear Interpolation for continuous data, Nearest neighbour allocation for classified data. Sampling occurred at profile locations and a 200m base grid developed for this project.

- A subset of locations with radiometric data within the profile and grid datasets was created using jmp (distributions).
- Classification tree modelling was undertaken using S-Plus 6.1 GUI on the profiles with radiometrics and all profiles.
- Classification trees were pruned to create a model with approximately 25% misclassification
- The classification models, with radiometrics as a covariate and without, were used to predict the abridged ASC suborder at the grid locations with radiometric data and without respectively.
- Jmp (http://www.jmp.com) was used to convert the data to text files and calculate the certainty of prediction at each location (using maximum(probability of abridged suborder at each location)).
- Data was transferred to ArcGIS, Displayed as x-y data. The predicted abridged ASC suborder and certainty were converted to raster format.
- To simplify the soil map, neighbourhood statistics were run to allocate the predicted soil type which forms the majority of a 3 by 3 cell (600m by 600m) rectangle around each cell.

Results

Data Collection

Figure 1 shows the digitised Land-use map obtained from NSW DNR derived using the ACLUMP protocol (Australian Collaborative Land Use Mapping Project, 2006). NSW DNR provided a number of digitised soil-landscape and regolith maps covering portions of the Namoi catchment (Coverage shown in Figures 2-3). The soil-landscape maps (Figure 2) were derived using traditional soil survey methods while the Brigalow Belt South project (Figure 3) used digital soil mapping methods (Soils Information Systems Unit, 2002). The locations of the collated soil point observations are shown in figure 4. Figure 5 shows the extent of radiometric data provided by the NSW DNR while figure 6 shows the magnetic data obtained from NSW DNR. Figure 7 shows the NDVI (Maxwell et al., 2002) derived from Landsat imagery and obtained from the University of Sydney. Figure 8 shows the spatial extent of a GIS developed as part of a research project at the University of Sydney (Crawford, 2003).

Figure 9 shows the DEM derived from the NASA SRTM data (http://srtm.csi.cgiar.org/). Figure 10 shows a number of primary terrain attributes derived from the NASA SRTM data. Figure 11 shows the topographic wetness index and figure 12 the MRVBF index, both derived using from the NASA SRTM data. Figure 13 shows the Hammond (1964) landform classification for the Namoi Catchment.

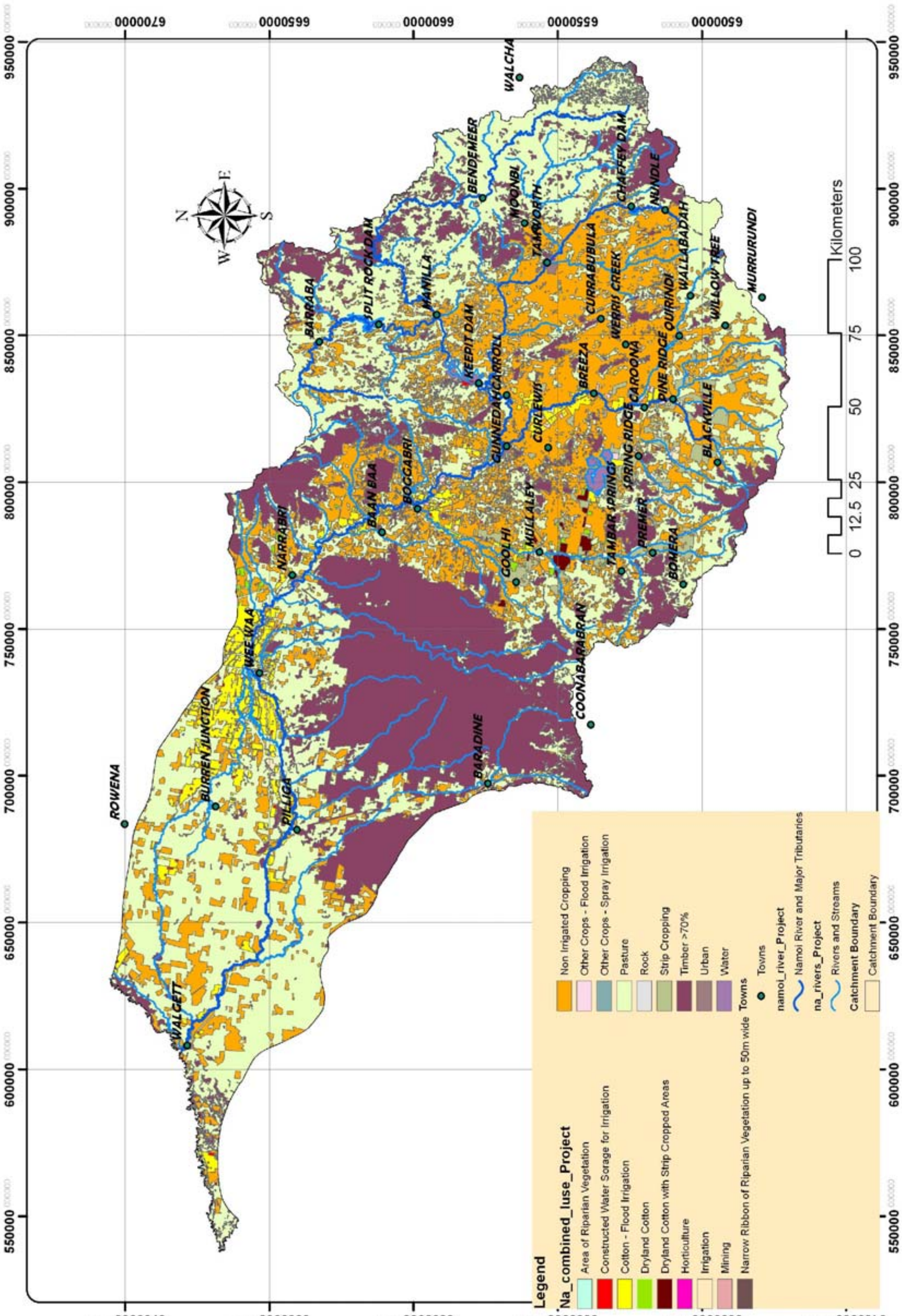

Figure 1 Landuse for Namoi Catchment, obtained from NSW DNR.

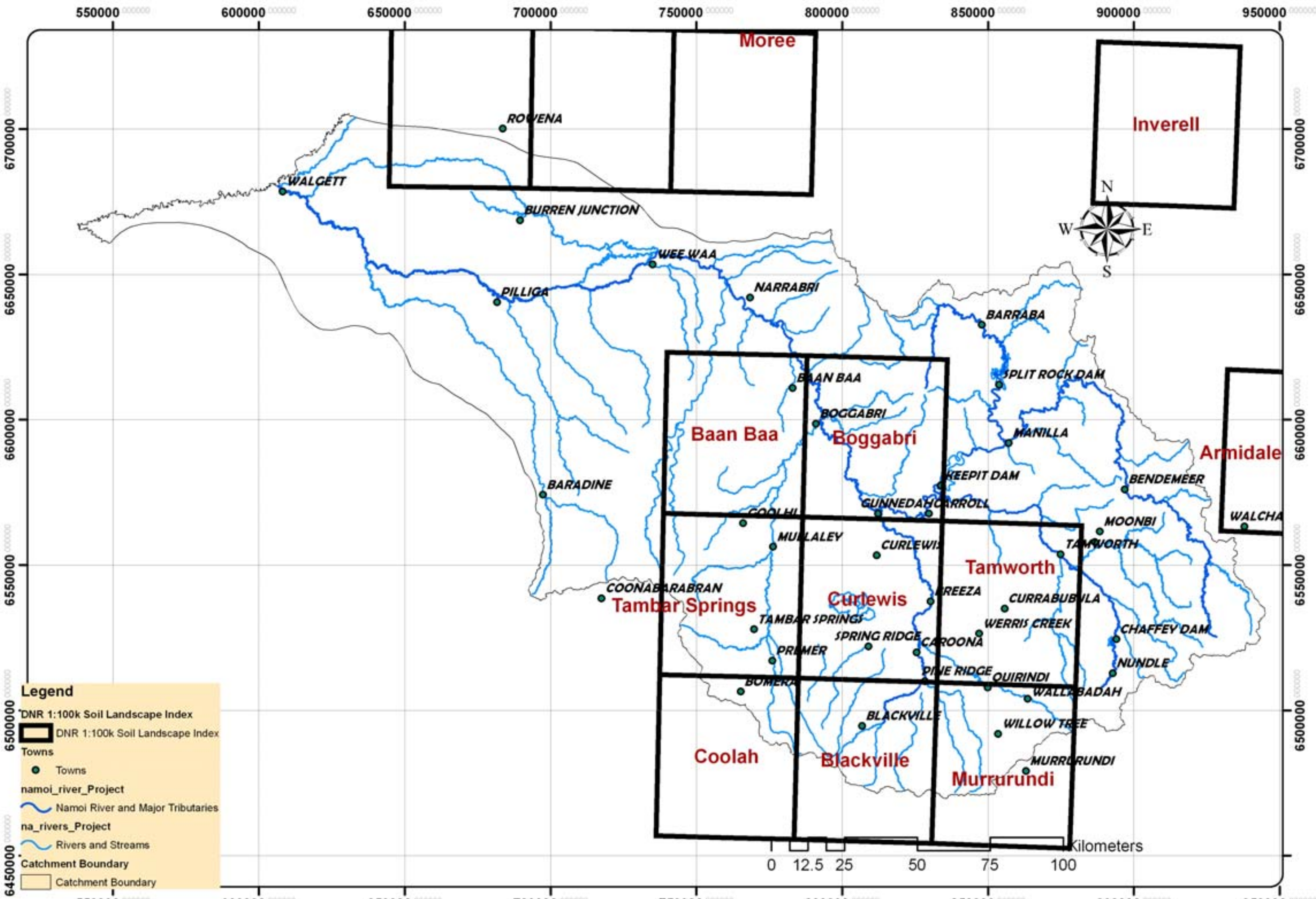

Figure 2 NSW DNR 1:100k Soil-Landscape map coverage.

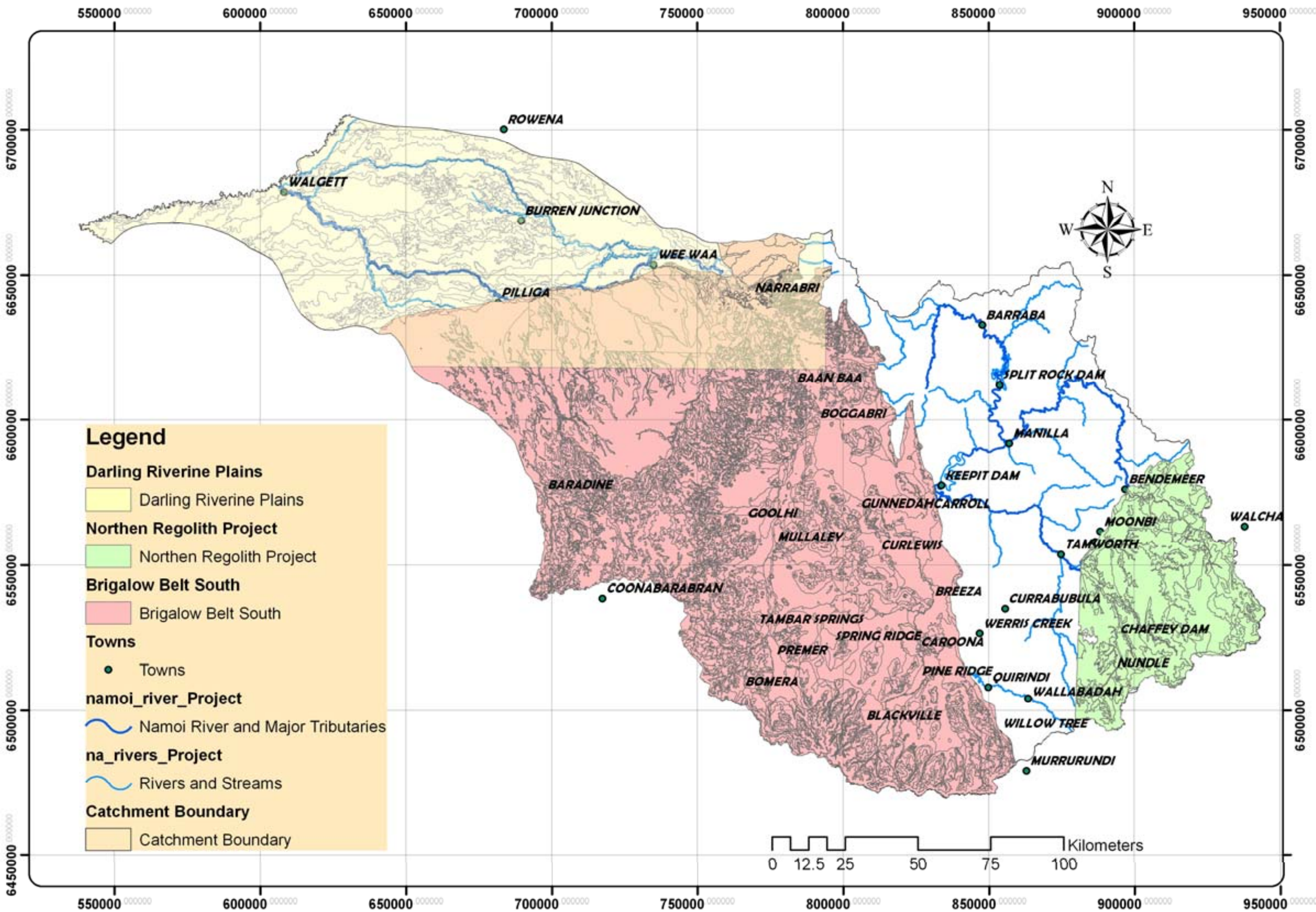

Figure 3 DNR polygon coverage

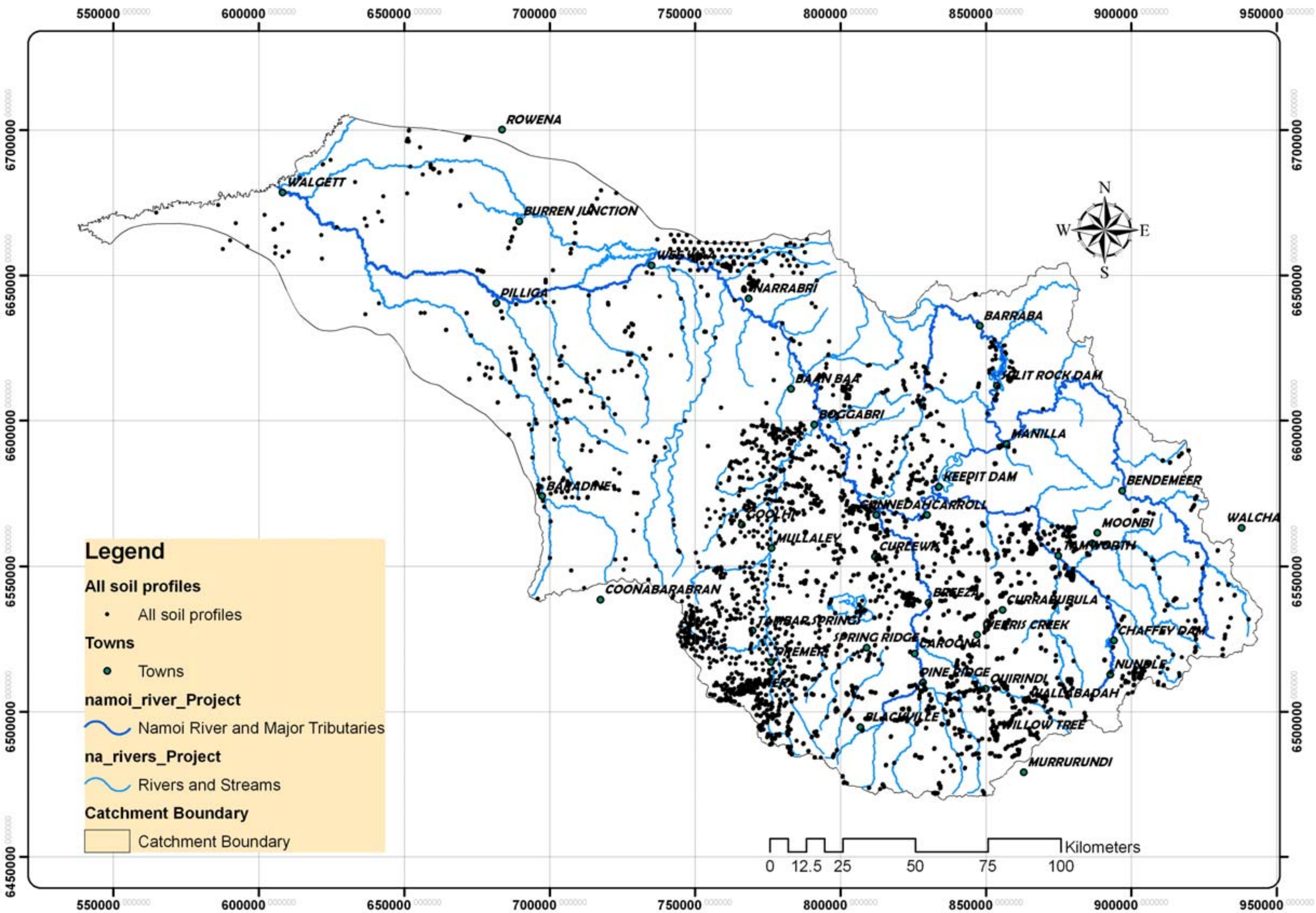

Figure 4 Soil point observation locations collated from NSW DNR, The University of Sydney, Cotton CRC and Gunnar Kirchoff.

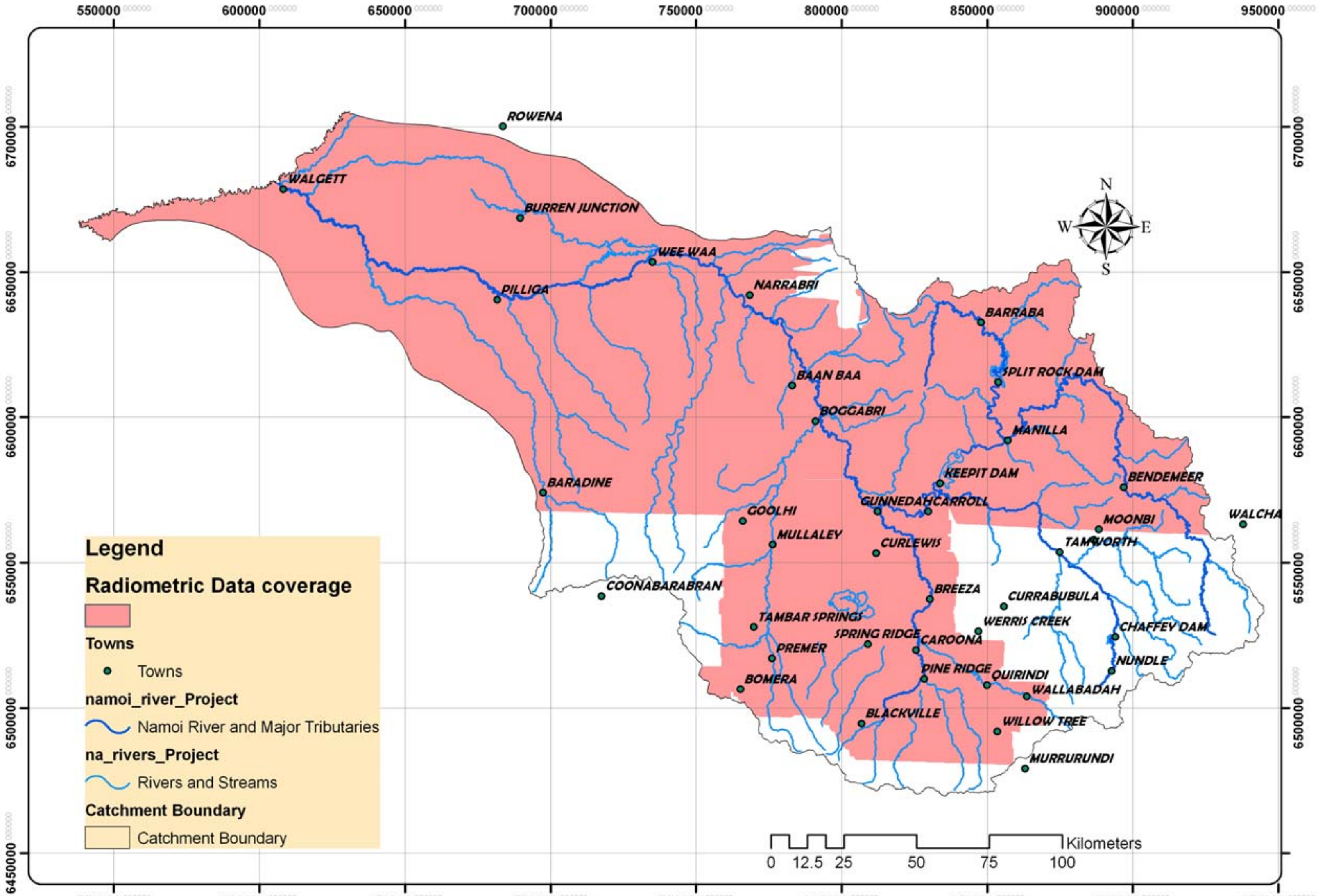

Figure 5 Radiometric Data coverage provided by NSW DNR.

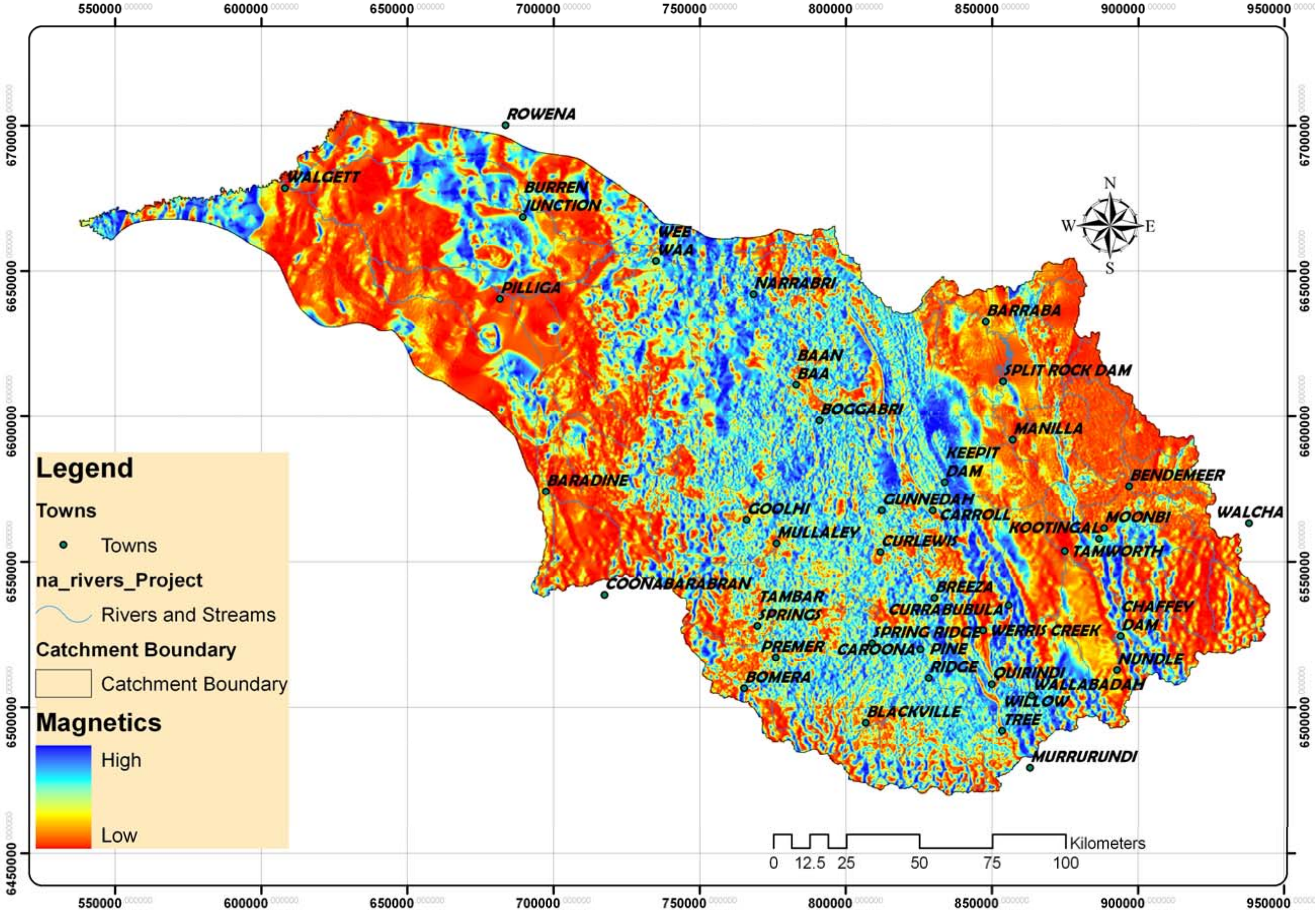

Figure 6 Magnetic Data provided by NSW DNR. Zone 55 and Zone 56 sheets mosaicked .

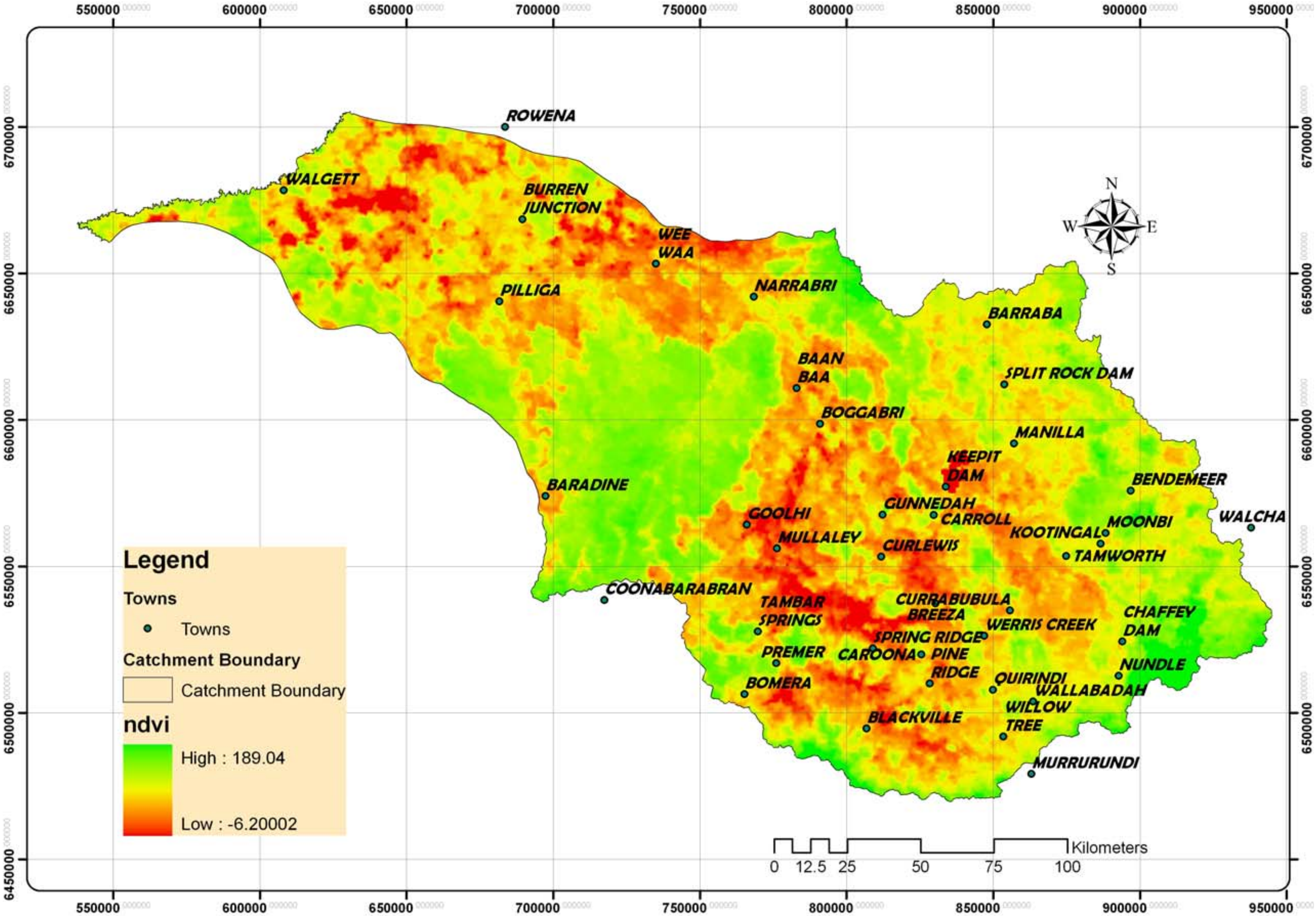

Figure 7 NDVI derived from LANDSAT imagery by The University of Sydney.

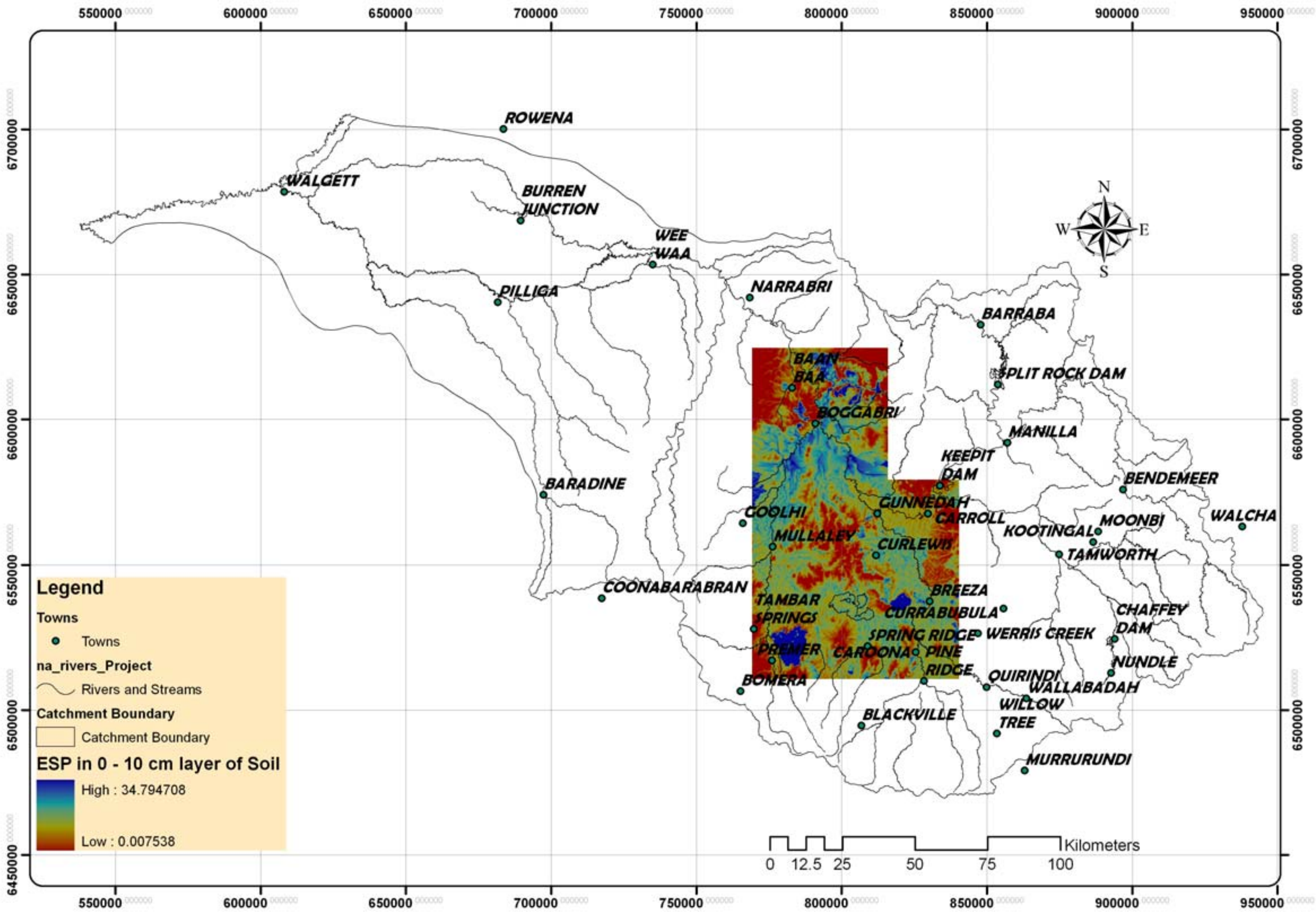

Figure 8 Area of Namoi Catchment covered by data collected for a research project by The University of Sydney (Crawford, 2003), This example shows Exchangeable Sodium Percentage (ESP) in 0 -10 cm layer.

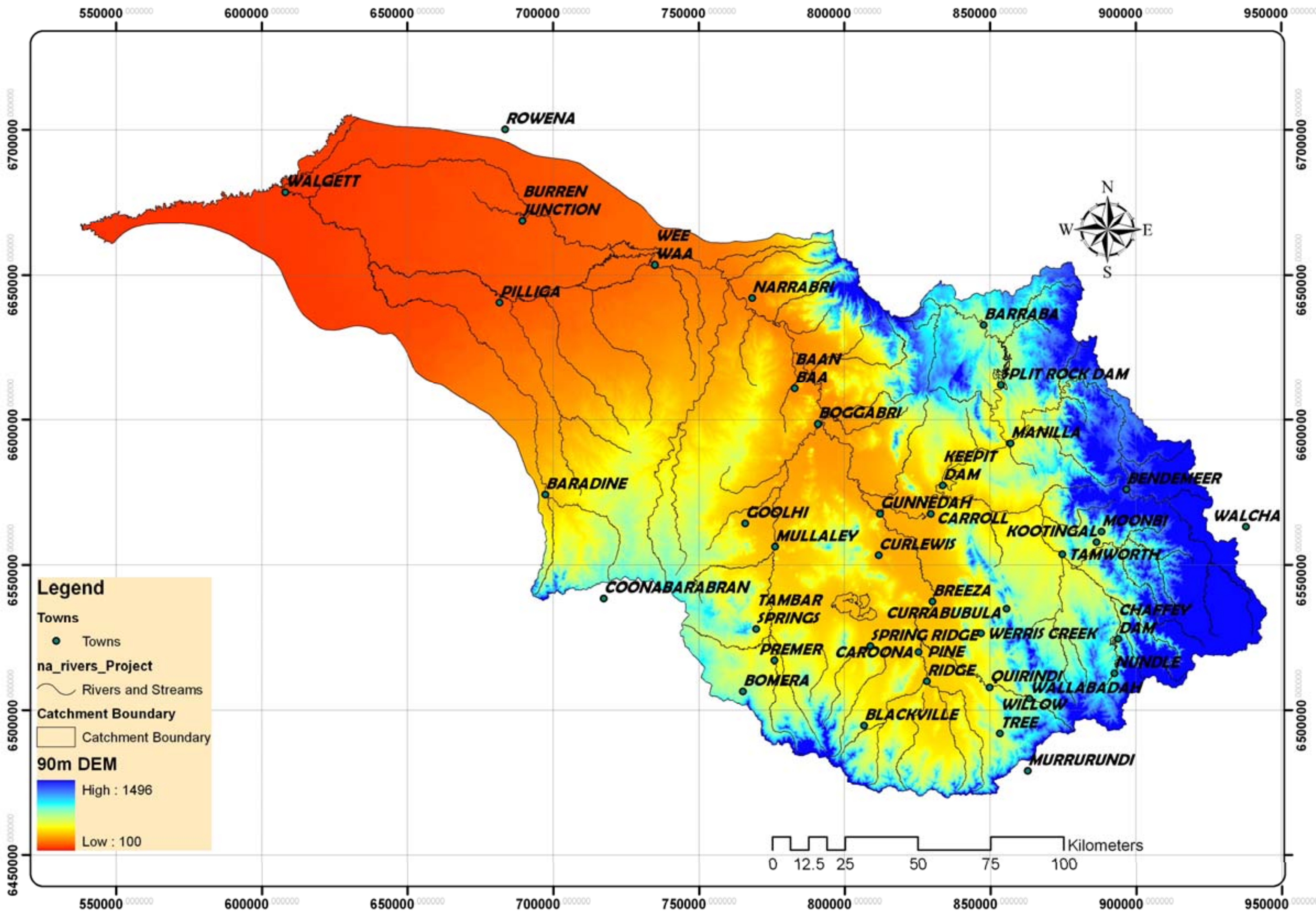

Figure 9 SRTM 90m DEM for Namoi catchment.

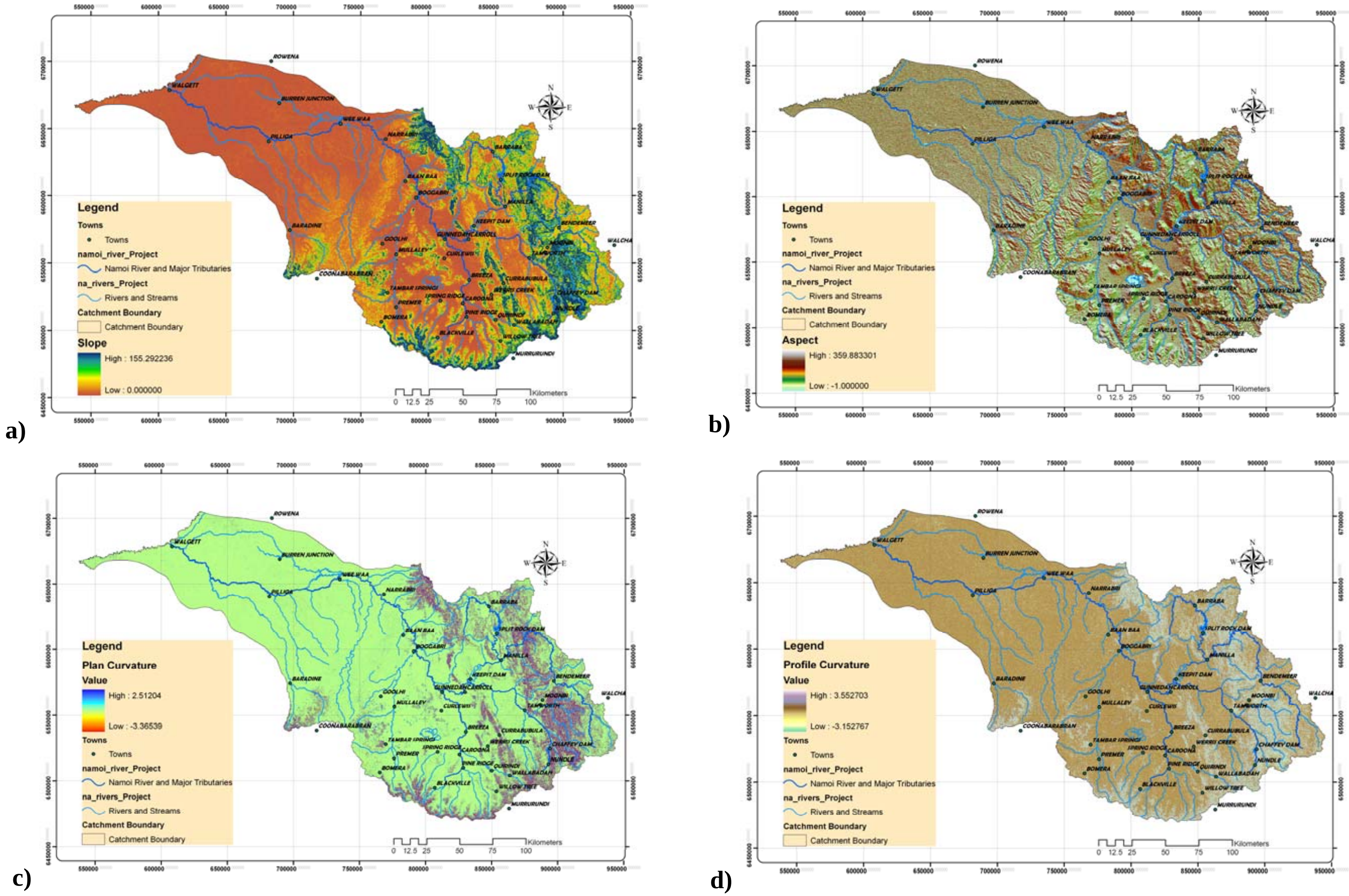

Figure 10 Primary Terrain Attributes derived from the NASA SRTM DEM a) Slope b) Aspect c) Plan Curvature d) Profile Curvature

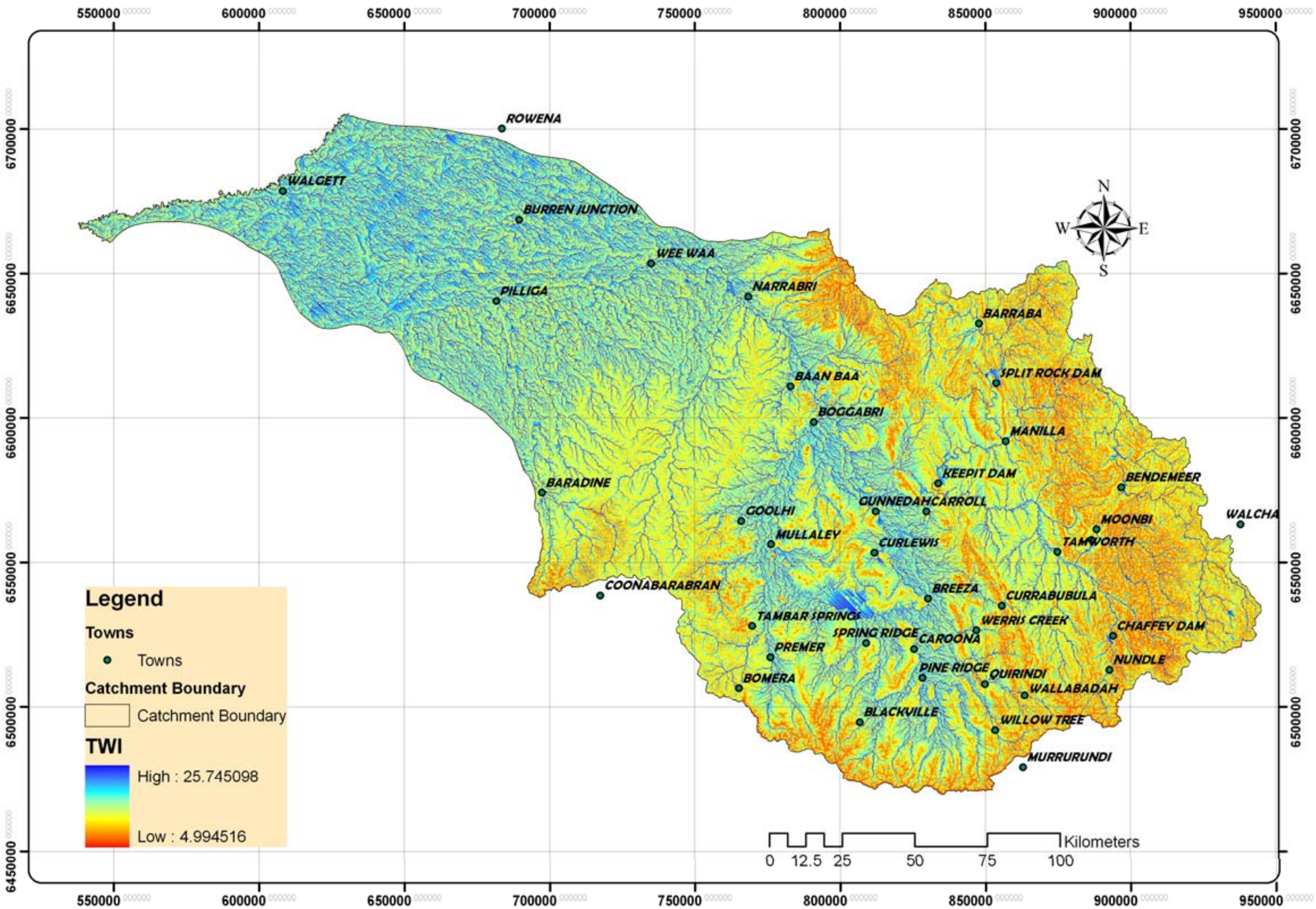

Figure 11 Topographic wetness index (TWI) for Namoi catchment.

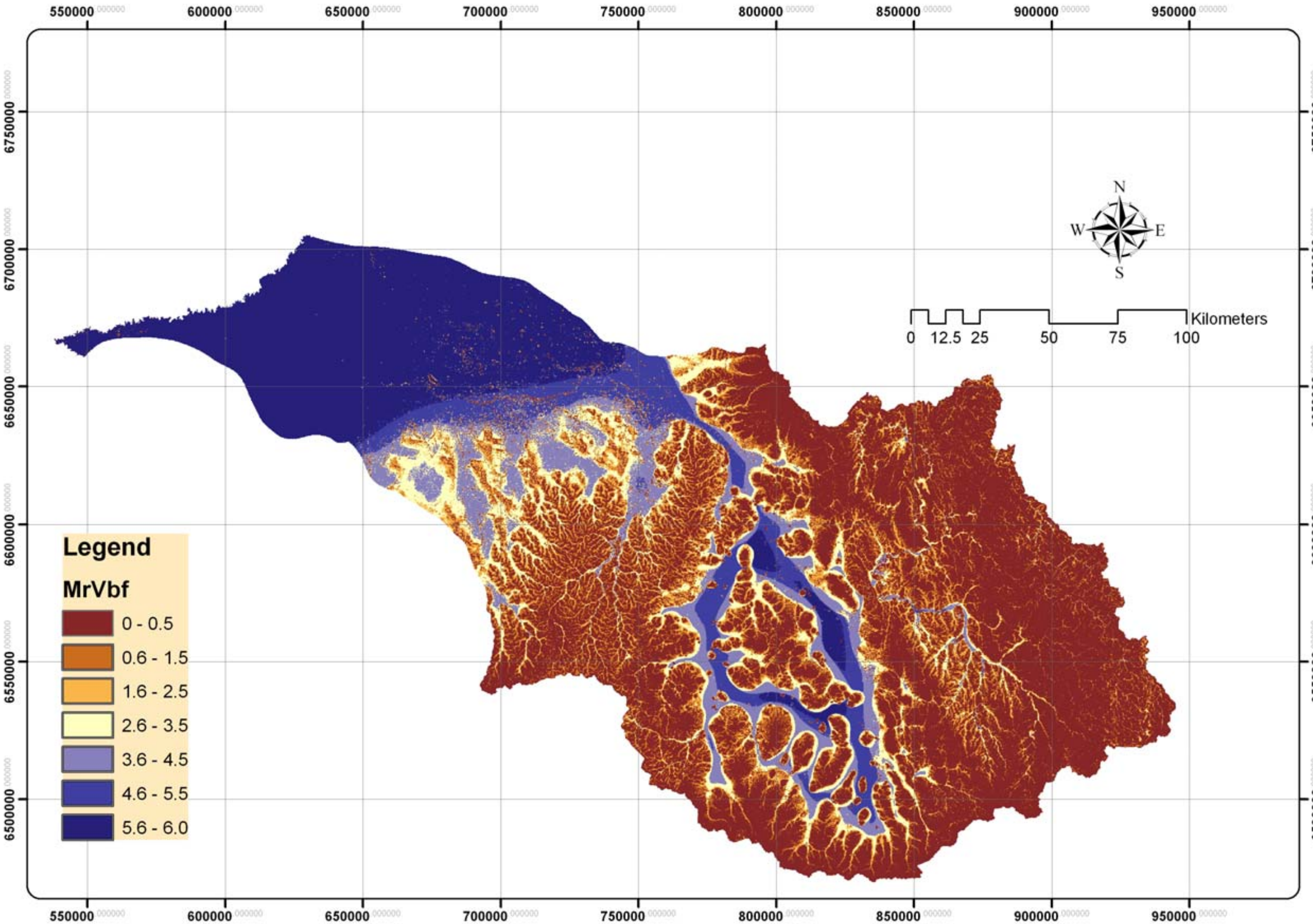

Figure 12 MrVbf (Gallant & Dowling, 2003) for Namoi catchment

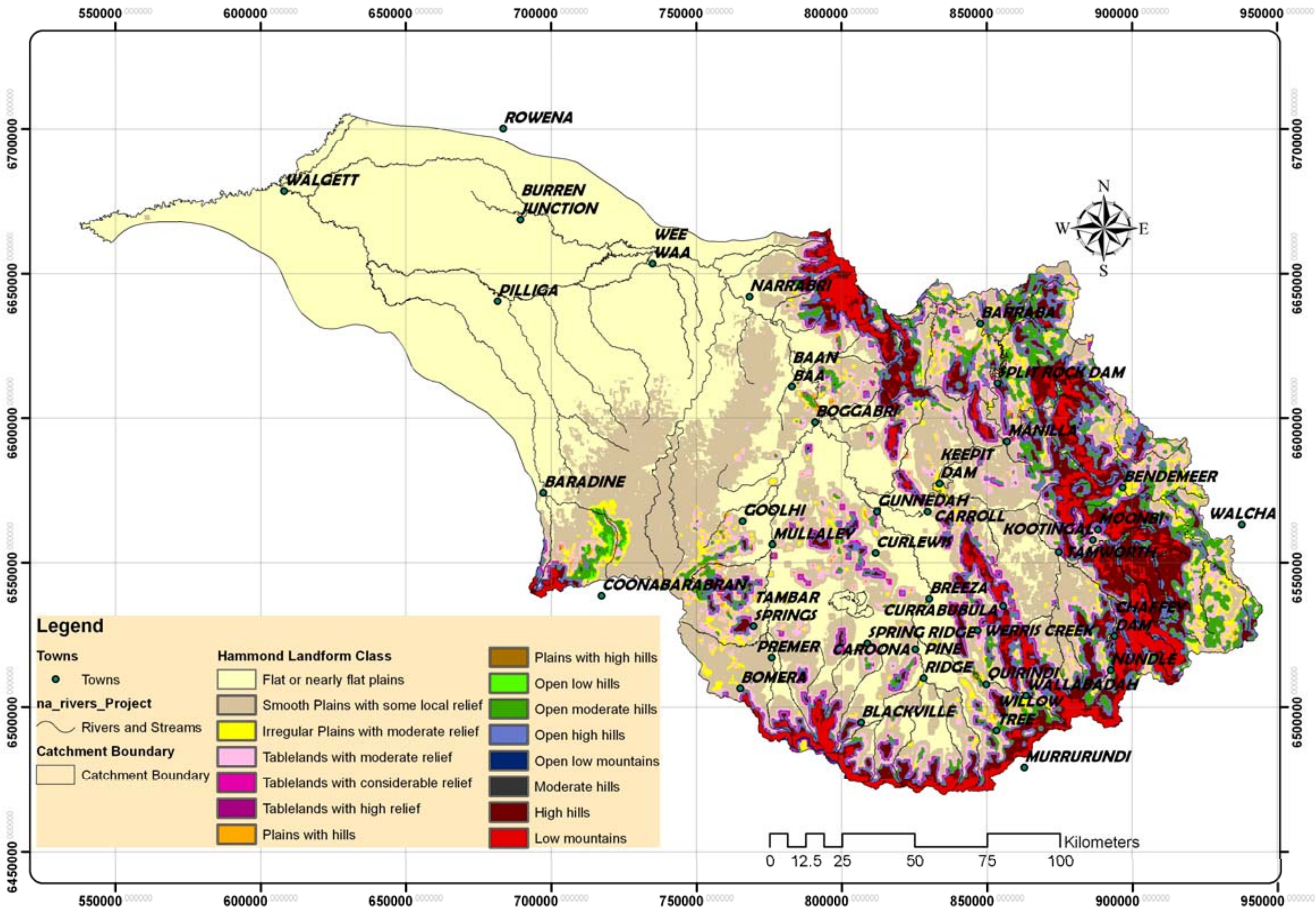

Figure 13 Hammond (1964) Landform classification for Namoi catchment.

Digital Soil Mapping component.

Figure 14 show the profiles available classified according to the Australian Soil Classification (Isbell, 1996). The results of two digital soil mapping exercises using SCORPAN models (McBratney et al., 2003) with classification tree algorithms (Lagacherie & Holmes, 1997; Moran & Bui, 2002) are shown in figures 15 and 17 with the prediction uncertainty of the algorithm using the gamma radiometric data is shown in figure 16. Misclassification rates for both digital soil maps were around 30%.

These maps provide a crude application of the SCORPAN model approach to digital soil mapping and the clearly show artefacts from the choice of predictors as well as ignoring the problems of the variable and disparate distribution of soil profiles available. The two maps do predict similar soil classes most of the extent covered by both mapping projects, however clearly this work must be further refined. Currently I am undertaking a research project at the University of Sydney considering methods of addressing problems associated with the distribution of soil point observation data using the Namoi catchment as the study area.

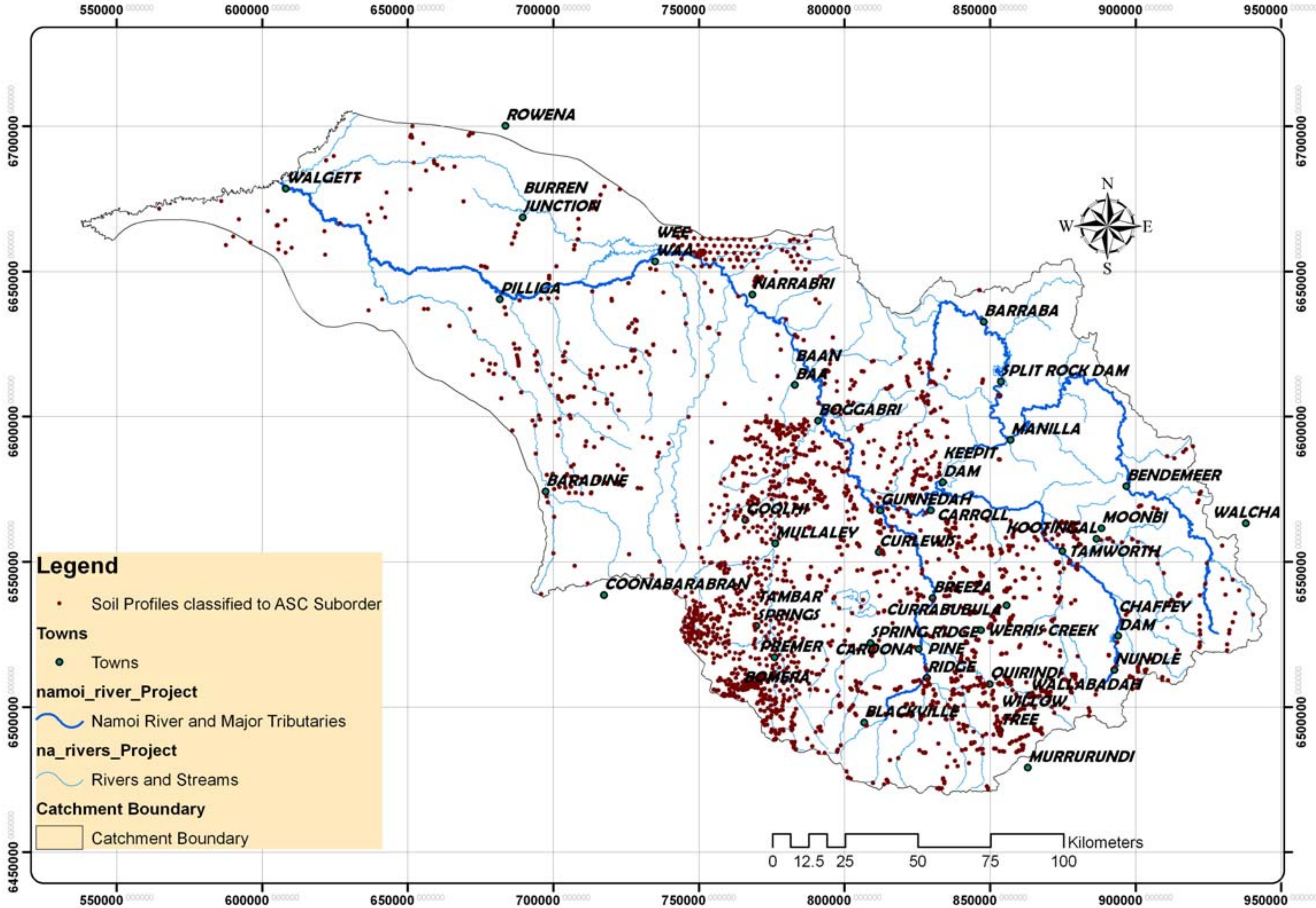

Figure 14 Location of Soil profiles with ASC suborder classification used in SCORPAN digital soil mapping of Namoi catchment.

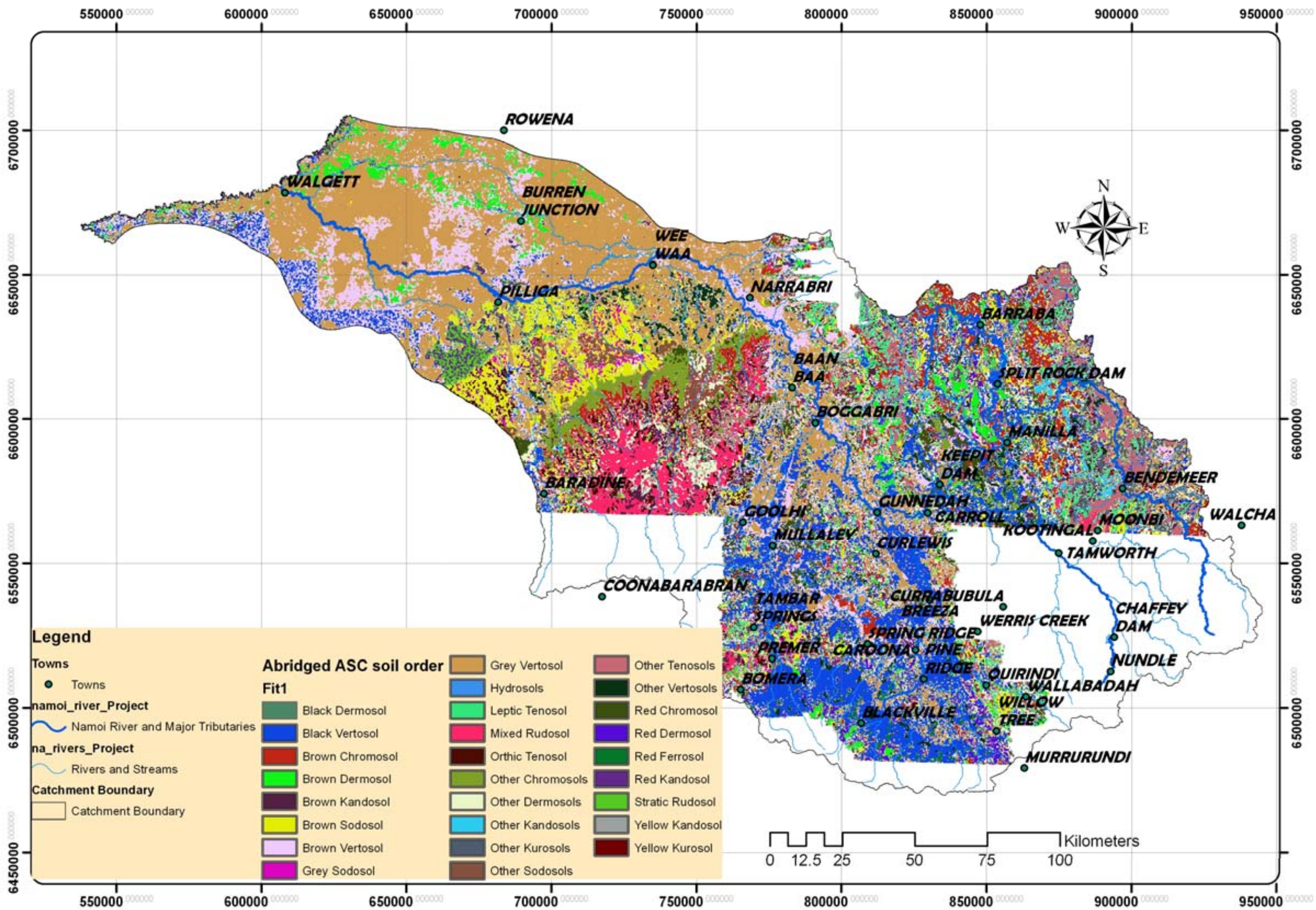

Figure 15 Digital soil map for the area of the Namoi catchment with radiometric data coverage produced using a SCORPAN model and classification tree algorithm

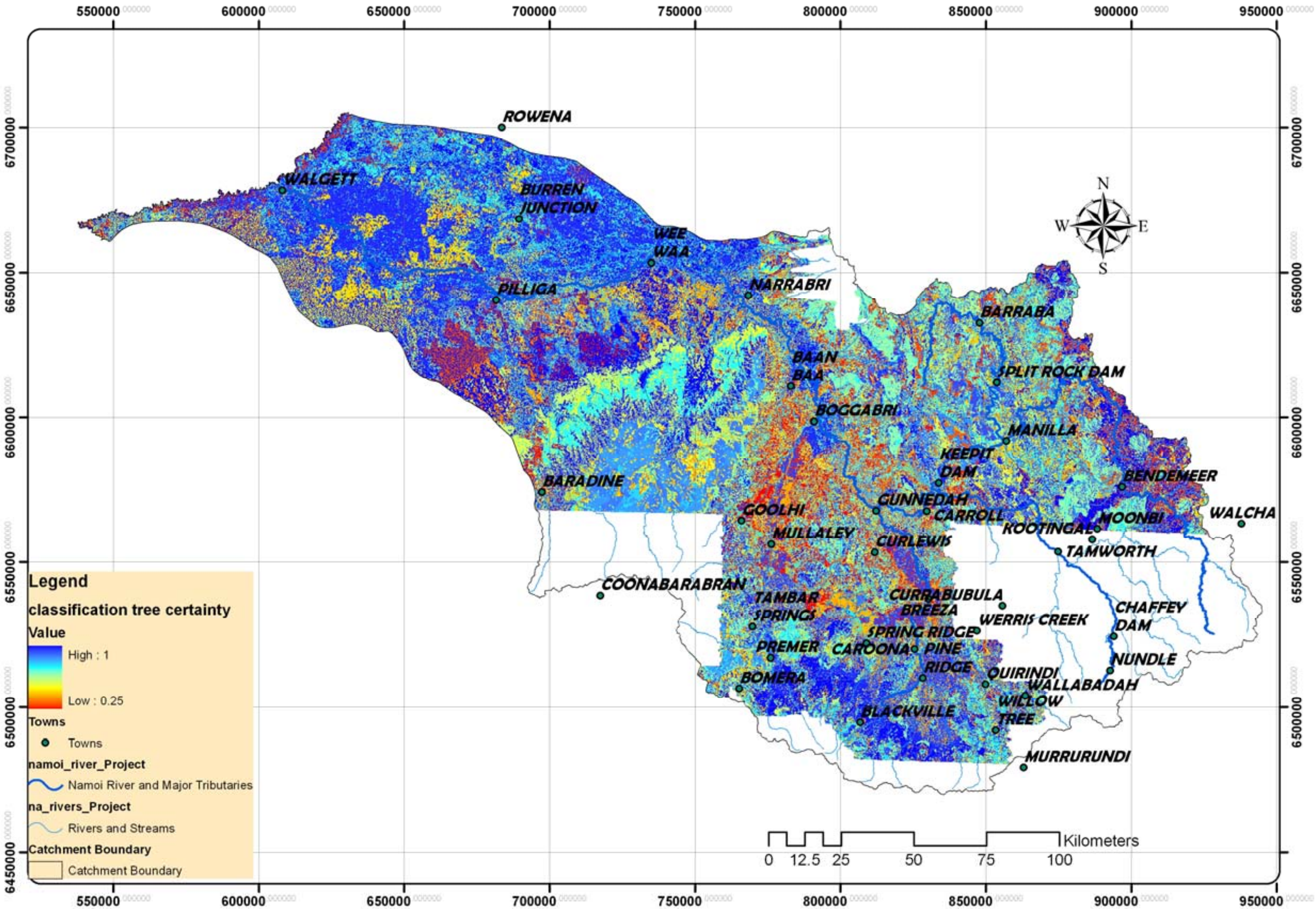

Figure 16 Certainty of classification of the digital soil map of the Namoi catchment (for soil map see figure 12)

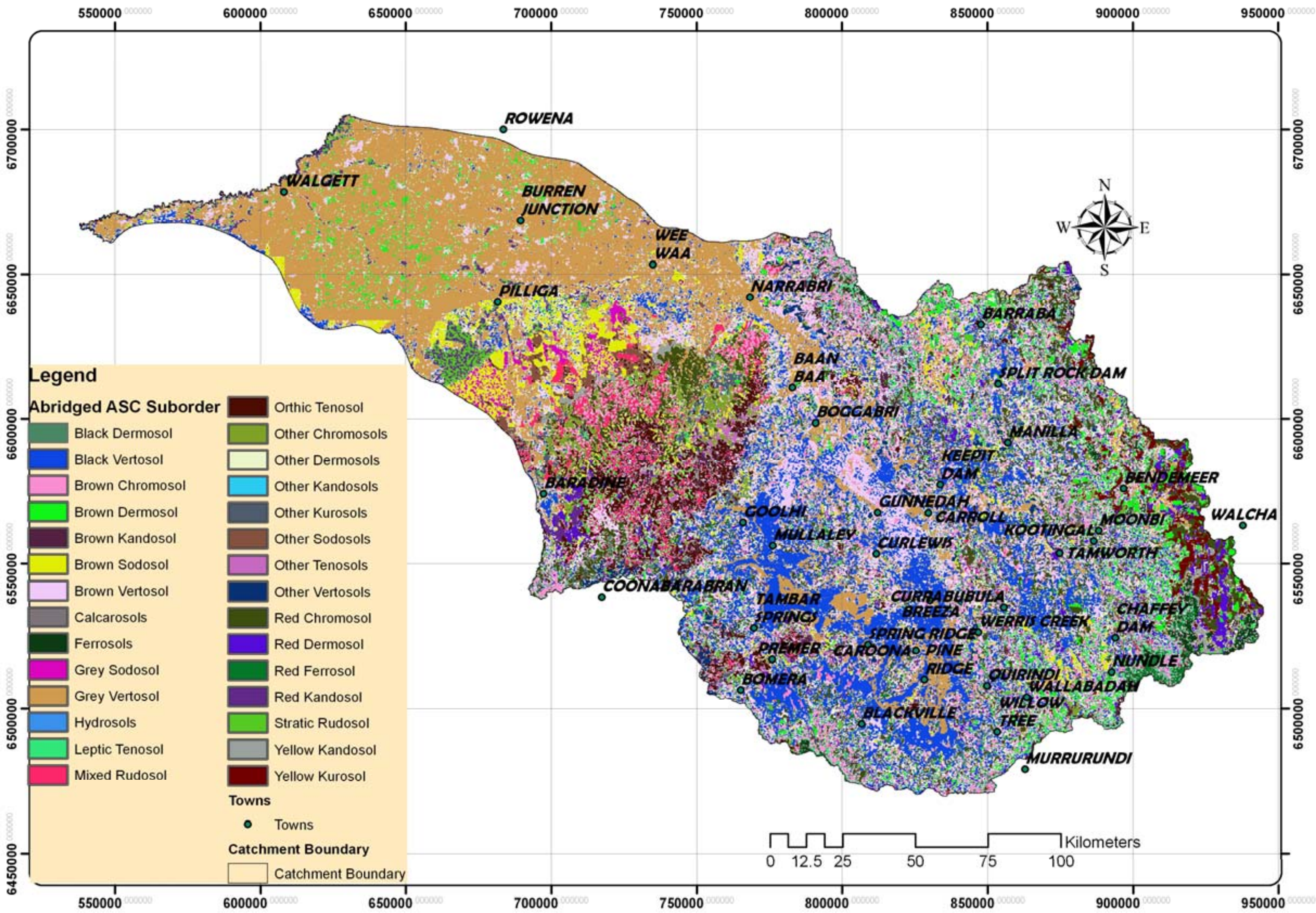

Figure 17 Digital soil map of abridged ASC Suborder using classification tree. No radiometrics but all other Covariates

Conclusions

- Soil data for the Namoi catchment, from a number of disparate sources, were successfully collated in a common location and projected into a common map projection. Unfortunately this does not represent all the existing soil information on the Namoi catchment as a number of individual researchers declined to release their data. By collating existing data, areas requiring further field work can be easily identified.
- The collation of geospatial data layers such as landuse, DEM, magnetics and landuse along with the derivation of numerous terrain attributes will provide a useful resource for the development of land management units for the Namoi Catchment Management Authority.
- The GIS provided to the Namoi CMA will be useful in environmental monitoring and management as well as providing a knowledge source for stakeholders within the Namoi catchment

Presentations and public relations

A copy of the GIS was provided to the Namoi Catchment Management Authority at the Completion of the Scholarship.

Acknowledgements

I would like to thank the Cotton Catchment CRC for providing funding for this project; Dr Inakwu Odeh for his support and guidance in supervising this project; Sheila Donaldson (Namoi CMA), Robert Banks of Soil Futures Consulting and Dr Gunnar Kirchoff for their assistance in locating soil and other geospatial information as well as my wife Catherine for her support during the project.

References

AUSTRALIAN COLLABORATIVE LAND USE MAPPING PROJECT. (2006). Guidelines for land use mapping in Australia: principles, procedures and definitiions (ed. A. G. B. o. R. Sciences). BRS Publications.

CRAWFORD, M. (2003). DIGITAL LAND FEATURE MAPPING FOR ENVIRONMENTAL AND CATCHMENT MODELLING IN THE UPPER NAMOI VALLEY, The University of Sydney.

DIKAU, R., BRABB, E. & MARK, R. (1991). Landform Classification of New Mexico by Computer. In *U. S. Geological Survey Open File Report 91-634*.

GALLANT, J. C. & DOWLING, T. I. (2003). A multiresolution index of valley bottom flatness for mapping depositional areas. *Water Resources Research* **39**.

HAMMOND, E. H. (1964). Analysis of Properties in Land Form Geography - an Application to Broad-Scale Land Form Mapping. *Annals of the Association of American Geographers* **54,** 11-19.

ISBELL, R. F. (1996). *The Australian Soil Classification*. CSIRO Publishing, Melbourne.

LAGACHERIE, P. & HOLMES, S. (1997). Addressing geographical data errors in a classification tree for soil unit prediction. *International Journal of Geographical Information Science* **11,** 183-198.

MAXWELL, S. K., HOFFER, R. M. & CHAPMAN, P. L. (2002). AVHRR channel selection for land cover classification. *International Journal of Remote Sensing* **23,** 5061-5073.

MCBRATNEY, A. B., SANTOS, M. L. M. & MINASNY, B. (2003). On digital soil mapping. *Geoderma* **117,** 3-52.

MORAN, C. J. & BUI, E. N. (2002). Spatial data mining for enhanced soil map modelling. *International Journal of Geographical Information Science* **16,** 533-549.

SOILS INFORMATION SYSTEMS UNIT. (2002). Soil Landscape Reconnaissance Mapping - Brigalow Belt South Stage 2. Department of Land and Water Conservation, Sydney.