A Multi-Disciplinary and Collaborative Approach for Defining Cadastral Boundaries and Recognising Traditional Customary Land

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Key words: Cadastre, Traditional and Customary Lands, Security of Tenure

SUMMARY

This paper discusses a large-scale, unique survey project conducted in Australia's Northern Territory. The focus is on delineating natural feature ambulatory boundaries along the coast of the Gulf of Carpentaria (intertidal zones) and adjacent major rivers (beds and banks) to facilitate land grants to formally recognize the land rights of Traditional owners. The collaborative project involved private industry, the Northern Territory Government, and national agencies, employing contemporary survey, geospatial, and hydrographic techniques. Notably, it required a multi-disciplinary approach across survey and geospatial fields to define the intertidal zones and the beds and banks of the land grant areas.

The administrative collaboration among various organisations and the consultation process are highlighted, detailing the strengths and weaknesses. The technical aspects of the survey, including establishing a vertical reference frame and using high-accuracy imagery and LiDAR observations, are explored. Due to the complexity of the project, a set of principles addressing land tenure and boundary delineation issues and considerations were developed for Licensed Surveyors in the Northern Territory. The paper concludes by emphasising the project's broader implications for Aboriginal land recognition and management, offering valuable insights for future cadastral initiatives.

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1. INTRODUCTION

Since the enactment of the *Aboriginal Land Rights (Northern Territory) Act 1976* (ALRA), which marked a significant step in recognising the land rights and custodianship of Aboriginal Australians in the Northern Territory of Australia (NTA), numerous land grants have occurred. These grants formally acknowledge the Aboriginal practice of land ownership by Traditional Owners (TO), providing empowering pathways for them to actively own, control, manage and utilise their land resources. Notably, and unlike previous land grants, this case stands out as the first to include the grant of land covering the intertidal zone, the beds and banks of a river, and to delineate these natural feature ambulatory boundaries through data or modelling analysis based on physical observations from multiple survey and geospatial information techniques.

The primary goal of the project is to define cadastral boundaries to encompass the specified land grant area in accordance with the recommendations of the ALRA's independent statutory administrator, the Aboriginal Land Commissioner (the Commissioner); and to then represent such boundaries unambiguously on survey plans and digital data. Briefly, the ALRA serves as the legal foundation for granting land to an Aboriginal Land Trust (ALT) in the NTA, guaranteeing inalienable freehold title for TOs. ALTs are made up of Aboriginal people from a specific land council region who work together to create a collective framework for customary land management and ownership.

Unlike previous cadastral surveys, this project is unique in its inclusion of the intertidal zone and the beds and banks of a river, and in its geospatial survey methods for defining the boundaries. The requirement to survey the land grant area facilitates the formal control, management, and ownership of land for TOs. The significance of the project lies not only in its objectives but in the collaborative and multi-disciplinary approach taken, involving private industry, government bodies, and national organizations to collaborate to define the land claim areas successfully and accurately.

The technical components of the survey included the connection to an International Terrestrial Reference Frame (ITRF) based geodetic datum, the establishment of a local vertical datum, tidal plane modelling, LiDAR observational data, Global Navigation Satellite System (GNSS) measurements and traditional surveying techniques. Certain challenges arose throughout the project, which necessitated the formulation of a set of principles and standards to guide Licensed Surveyors in the NTA in defining such natural feature ambulatory boundaries.

In large-scale projects involving diverse professionals and stakeholders, challenges arise from varying expertise and communication gaps. Transparent collaboration is crucial from the project's outset, particularly across knowledge-sharing and discussion involving land tenure, surveying, geospatial data, and legalities. Transparency ensures meeting expectations and explaining data interpretations for those less familiar with scientific information. Future engagements should prioritise the consensus on definitions and approaches before surveys, learning from past experiences where certain project outcomes may not have been evident initially, emphasising the importance of clear communication and confidence in such intricate endeavours.

2. ALRA AND LAND CLAIM PROCESS

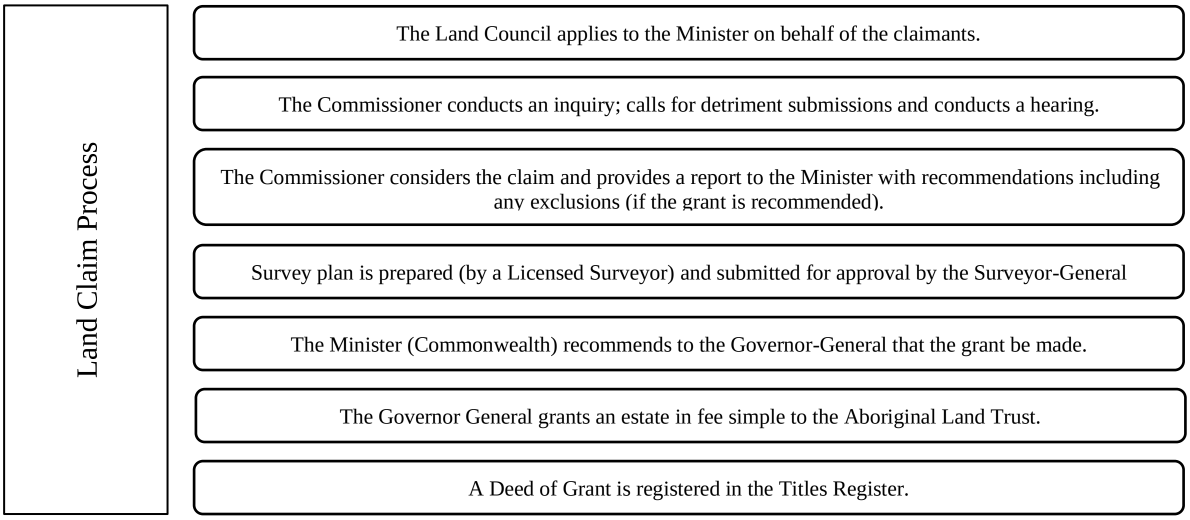
The ALRA was first enacted in 1976 and has since been amended numerous times, including the addition of a sunset clause stating that no new land claims could be filed after 30 June 1997. The latest Aboriginal Land Commissioner report (Commonwealth of Australia, 2023) stated that of the 249 land claim applications:

a) 93 have been the subject of inquiries and reports.
b) 2 are currently the subject of incomplete inquiries.
c) 149 have been disposed of either by way of withdrawal or some other process not involving an inquiry; and
d) 5 are currently the subject of settlement negotiations which may result in the applications being disposed of without an inquiry.

Of these land claims, 23 are related to the intertidal zone and beds and banks of a river. The content of this paper is in reference to 5 of these land claims that cover part of the Gulf of Carpentaria, namely, Garrwa LC No. 178; McArthur River LC No. 184; Manangoora LC No. 185; Seven Emu LC No 186; and Wollogorang LC No. 187.

The ALRA states that only unalienated Crown land or land owned entirely by Aboriginal people could be claimed. The TOs must demonstrate their customary relationship with the land under claim for their land claim to be successful. Claimants must provide the Commissioner with evidence as well as extensive research conducted by anthropologists. The Commissioner must be satisfied that the claimants are the rightful TOs before recommending the land be granted to the Minister of Aboriginal Australians, providing additional comment on any detriment should the land be granted and how that may affect existing or proposed patterns of land use in the area. In turn, the Minister makes a recommendation to the Governor-General to grant all or a portion of the land under claim (Central Land Council, 2024).

The TOs, as defined in the ALRA, are a local descent group of Aboriginal people who have common spiritual responsibility for sacred sites on a piece of land, and who are entitled by Aboriginal tradition to hunt and gather on that land. The TOs are the key decision makers for their land and are represented by a Land Council. There are four Land Councils that cover the NTA: Anindilyakwa, Central, Northern, and Tiwi.



The Surveyor-General's role in the land claim process is to provide advice and guidance on survey requirements and land tenure for the claim area. This may include indicative maps, survey process (including techniques) during the inquiry stage.

The Licensed Surveyor's role in the land claim process is to determine and delineate the boundaries of the land claim area, as described, and recommended by the Commissioner, using their expert knowledge in boundary determination, land tenure, and measurement. The Licensed Surveyor also produces the survey plan (and data) to represent the definition of the land grant and submits the survey to the Surveyor-General for approval.

It needs to be recognised that the Aboriginal land claim process and the rights granted to Aboriginal groups by the ALRA are not the same as native title claims, which are governed by the *Native Title Act 1993*. Native title is the recognition of Aboriginal Australians' rights and interests in land and water under their own traditional laws and customs. For native title to exist, claimants must demonstrate a continued connection to the land and water in accordance with their traditional law. This is automatically extinguished when the land is granted tenure that allows for exclusive possession (e.g. private freehold, residential, and commercial leases). Exclusive native title rights grant proponents exclusive rights over all others (typically over vacant Crown land in towns). Non-exclusive native title holders have no control over who has access to their lands (which is often determined over pastoral leases).

3. LAND SURVEY PROCESS

The National Indigenous Agency Australia (NIAA), a Commonwealth body, initiated and oversees the project. An Approach to Market (ATM) was created and advertised, inviting contractors to submit proposals for the work. As part of the ATM formulation and project requirements, the NIAA held consultations with various government bodies, Aboriginal groups, and their representatives. This consultation included a discussion with the Northern Territory Government's (NTG's) Land Information Group (LIG) about the land survey process and requirements for the land claim to be granted under NTA law.

3.1 Consultation Processes

The consultation process occurred prior to, during and after the successful tender of the project to the supplier. This involved the TOs, Land and Sea Rangers, and the Aboriginal Areas Protection Authority (AAPA), who all informed NIAA and the supplier of culturally sensitive and sacred areas within and near to the land claim area. As an outcome of the consultation, and as part of the requirements of the project, the TOs and Land and Sea Rangers accompanied and advised the surveyors on site on areas of particular cultural importance that should be avoided.

Regarding the ATM document, the NTGs LIG, and the Northern Land Council (NLC) who represent the claimants, were consulted regarding the content, methodology and general approach outlined in the ATM. As part of the ATM and the consultation process, it was agreed to between the stakeholders (being the NLC, other NTG Departments, the principle, and the NIAA) that a smaller technical working group be formed, where the Licensed Surveyor and the LIG would consulate with the NLC technical team on their methodologies and decision-making processes. This consultation process was seen as a means for the Licensed Surveyor to share draft survey plans / data, their processes and address any queries or concerns as well as an opportunity to seek feedback on difficult areas, which could then be progressed to the stakeholder working group for directive and for boundary endorsement. Upon consensus amongst stakeholders, a recommendation for the survey plan to be approved is put to the Surveyor-General

The consultation process from a staged survey project perspective is ongoing and iterative, especially as the Licensed Surveyor continues their finalization of the land claim boundaries. Further consultation will be required for matters such as potential encroachment of infrastructure or occupations, and additional exclusions from the land claim area that are discovered during the field survey.

3.2 Tender Process

The preparation of the ATM was influenced largely by the technical specifications required to accurately delineate the land claim boundaries. The LIG (the NTG office responsible for the regulation of cadastral surveying and geospatial information matters within the jurisdiction) advised on the survey requirements. The specifications provided were in line with the nationally recognized standards as per the respective industry bodies and are listed below:

- SP9 Australian Tides Manual (Intergovernmental Committee on Surveying and Mapping (ICSM)).
- Hydroscheme Industry Partnership Program – Statement of Requirements (Australian Hydrographic Office (AHO)).

– Aerial Photo Technical Specifications (LIG).
– Digital Topographic Mapping Specifications (LIG).
– Elevation and Depth Data (ICSM).
– LiDAR Specifications and Tender (ICSM).
– Standard for the Australian Survey Control Network SP1 (ICSM); and
– Standards and Directions listed on the Surveyors Board of the NTA.

The ATM was broken down into several components with the potential supplier responsible for the delivery of:

Preparation of work plans

- Detailed plans and timeframes for each task
- Provision of aerial imagery 'flight plans' prior to survey commencement

Risk assessment plans

- Work health and saftey plans
- Heritage and environmental plans

Relevant approvals

- Heritage, environmental and culutral clearances
- Approvals for the surveying of roads and service infrastructure
- Permissions from relevant landowners and authorized land users

Survey and geospatial observations and data collection

- Tidal observations as per specifications
- Geospatial techniques and models as per specifications
- Ground control survey as per specifications
- Preliminary data and models to be submitted to the LIG for assessment with analysis and verification from the AHO and Geoscience Australia (GA)

Determination of boundaries and consultation

- Collaboration with the LIG to plot and determine intertidal zone and beds and banks boundaries
- Attend consultation sessions with relevant stakeholders
- Redrafting of survey plans dependent on consultation outcomes

Drafting and lodgement of survey plans

- Once boundaries are agreed to the satsification of the Surveyor-General, meet all necessary specifications, then survey plans may be lodged for approval by the Surveyor-General

Survey and geospatial techniques

- Tidal observations
- Aerial imagery
- LiDAR
- Ground control surveys
- Verification surveys
- Cadastral surveys
- (Further discussed in Section 4)

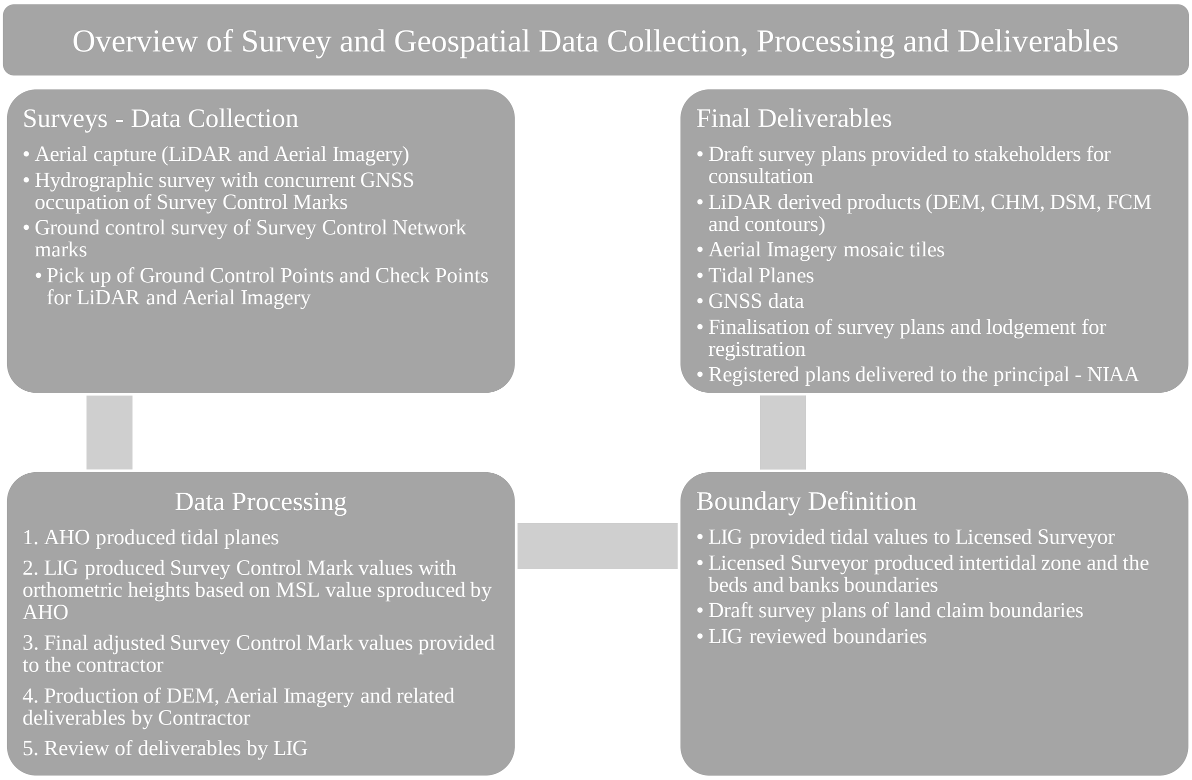
The tender was ultimately awarded to an Indigenous owned and operated geospatial firm at the discretion of the NIAA with technical input from the LIG.

4. SURVEY AND GEOSPATIAL DATA AND MODELS

The total area that was required to be survey spanned 2,600 km^2. The geospatial surveys provide an efficient and accurate method to allow the Licensed Surveyor to define natural feature boundaries for the intertidal zone and the beds and banks of a river over such a large area of interest. The boundaries required to be defined are ambulatory in nature, meaning that they can change overtime through slow and imperceptible accretion or erosion. The collection of geospatial data allows the Licensed Surveyor to delineate the boundaries at a specific epoch, providing an accurate representation of the location of the natural feature boundaries at that particular point in time.

The intertidal zone boundaries are defined as the area between the Mean High Water Mark (MHWM) and the Mean Low Water Mark (MLWM).

The beds and banks of a river boundaries are defined as: in the tidal part of rivers, the area between the top of banks delineated by the MHWM; and for non-tidal parts of a river, the area between the top of banks.



4.1 Tidal Plane

To ensure accurate tidal values, a tidal plane model was developed using observations gathered across the land claim area. Tide gauges (TG) were strategically placed along the approximate 200-kilometre coast of the Gulf of Carpentaria. Six TGs were positioned near major river mouths, while four were installed close to the tidal section's end in the designated bed and bank claim areas.

Tidal data collection spanned a minimum of 35 days, following the guidelines outlined in the ICSM in the *Australian Tides Manual, Special Publication No.9*. Adherence to this document and the AHO specifications was met. Please note, the hydrographic work was undertaken by qualified hydrographers certified by the Australasian Hydrographic Surveyors Certification Panel Level 1 and in accordance with International Hydrographic Organisation.

The obtained data quality varied at each TG, with measurements ranging from ± 0.16m to ± 0.21m. Tidal harmonic analysis was then conducted by the AHO to determine the relevant tidal levels, namely the MHWM and the MLWM. This approach aligned with the specified standards and regulations.

4.2 Reference Frames

4.2.1 Horizontal Reference Frame

The horizontal reference frame for the project was the Geocentric Datum of Australia 1994, which is the legislated datum for cadastral surveys in the NTA. It is a static coordinate datum based on the International Terrestrial Reference Frame 1992, held at the reference epoch of 1 January 1994.

For this project, the size of the survey area required a Global Navigation Satellite System (GNSS) control survey, where 47 Coordinated Reference Marks (CRM) were used, with 44 CRMs placed. Each CRM was observed for 12hrs+ using static GNSS to allow for an AUSPOS solution. All adjacent CRMs were occupied and observed simultaneously to allow for a GNSS network processing and a least squares estimation adjustment. The static GNSS survey was performed in accordance with the Provisional NT Standards and Guidelines for the use of Control Surveys and the ICSM’s Guidelines for Control Survey by GNSS SP1.

The horizontal positional uncertainty for the survey ranged between 0.014m and 0.015m for each CRM.

4.2.2 Vertical Reference Frame

To determine the most appropriate vertical reference surface to plot the MHWM and the MLWM, a thorough analysis incorporating tidal plane data and a harmonised vertical datum was required.

The legal height datum of Australia is the Australian Height Datum (AHD). The AHD surface passes through Mean Sea Level (MSL), as realised between 1966 and 1968, at 30 tide gauges and through points at zero AHD height vertically below the other basic junction points. AHD heights are realised through heights published on survey marks. AHD was determined to be unsuitable as the height datum for the intertidal zone and beds and banks surveys as the MSL of AHD is not current or generally not directly accessible in the areas of interest, nor were there any survey marks with AHD in the vicinity.

To define the MHWM and the MLWM, known tidal planes were required. A hydrographic survey undertaken to the required standards as prescribed by the AHO was performed. The MSL defined by the survey was adopted as the height datum for the extent of the area under survey.

The adopted MSL was propagated throughout the network of Survey Control Marks (SCMs) to provide control for the LiDAR and aerial imagery surveys. The same number of CRMs and the same method of observation was used for the vertical control survey as the horizontal control survey.

GNSS uses the ellipsoid as its reference surface for height, providing an ellipsoidal height. This differs to AHD and the adopted local MSL as both are orthometric height datums. A geoid model that is aligned with the reference ellipsoid was used to derive orthometric heights from GNSS ellipsoidal heights.

The geoid used should be the best model available for the area under survey. Two options are available:

- AUSGeoid2020, which was determined to be unsuitable for the project because it is modelled to fit AHD. This distorts the geoid model in order to fit the AHD inputs and ignores the ocean’s mean dynamic topography. The geometric aspect of AUSGeoid2020 is made up of this modelling.
- Australian Geometric Quasigeoid (AGQG), which is the gravimetric part of AUSGeoid2020. AGQG was used as it is the best available geoid model for height propagation across the survey area.

Using the surveyed MSL and the AGQG, propagation of height from the tidal gauge buoys (TGB) used in the hydrographic survey through the survey control network followed the below process.

- Once height values were selected in a tidal datum and a local height datum was chosen, the transformation from the tidal datum to the terrestrial local height datum occurred.
- The SCM closest to the tide gauge buoy (TG-SCM) was occupied to co-capture GNSS data with the GNSS receiver on the TGB.
- The ellipsoidal height of MSL was calculated for the TGB. Comparing this to the ellipsoidal height of the TG-SCM provided an offset height that was used to compute the TG-SCM’s MSL height.
- A least squares adjustment of the GNSS survey network for the entire survey control network was undertaken with the MSL height of the TG-SCM’s constrained.

- The AGQG was used to model the geoid-ellipsoid separation throughout the area under survey and provided the MSL values for each of the SCMs.
- After this process, the DEM was used to plot the corresponding tidal levels, i.e. MHWM and MWLM, as derived from the tidal plane model.

Using the NT and Queensland border CRM as an example:

- The AUSPOS observation (36 hours 45 minutes 30 seconds) had an ellipsoidal height uncertainty of 0.026m (at the 95% interval) and an AUSGeoid2020 AHD uncertainty of 0.226m (at the 95% interval).
- Taking into consideration the tide gauge uncertainty (0.18m) and the AGQG uncertainty (0.112m), the combined calculated uncertainty at this CRM is 0.214m.
- The project’s method and use of AGQG has improved the height uncertainty by 0.012m compared to the uncertainty associated with AHD.

The average positional uncertainty for height across the survey is 0.213m.

4.3 LiDAR and Aerial Imagery

4.3.1 <u>LiDAR</u>

The collection of the LiDAR data underpinned the data-driven approach in determining the intertidal zone and tidal river boundaries, as well as the development of models for non-tidal river boundary analysis. As a result, the data collection of LiDAR along the intertidal zone was captured within a two hour period of the predicted low tide. The LiDAR data collected met specifications with a horizontal accuracy achieved of ± 0.8m and a vertical accuracy of ± 0.3m. The acquisitions occurred over six days with approximately 3000 ground control points being sampled, with 98.9% being accepted.

The deliverables were:

- LiDAR Point Cloud Type 1 Classification, tiled data (500m x500m)
  Lidar derived products:
  - Hydroflattened DEM
  - Hydroflattened Digital Surface Model
  - Canopy Height Model
  - Fractional Cover Model
  - Contours (o.5m intervals)

4.3.2 <u>Aerial Imagery</u>

Aerial imagery was obtained to aid in boundary determination and to provide up-to-date land information over the land claim area. The aerial imagery was flown at low tide over 40 flight runs at a ground sampling distance of 15cm resulting in an RSME of ± 0.3m, meeting specifications. The acquisitions occurred over four days, with 59 ground control points being used for the aero-triangulation adjustments, which involved 59 flight runs.

The deliverables, being in a 3 band ortho product (RGB), were:

- 8 ECW Mosaic
- 17 JPG2000 Mosaic
- 25 Mosaic Boundary (shapefile format)

The device used for image capture was an UltraCam Eagle Prime 100 with a lens focal distance of 100mm.

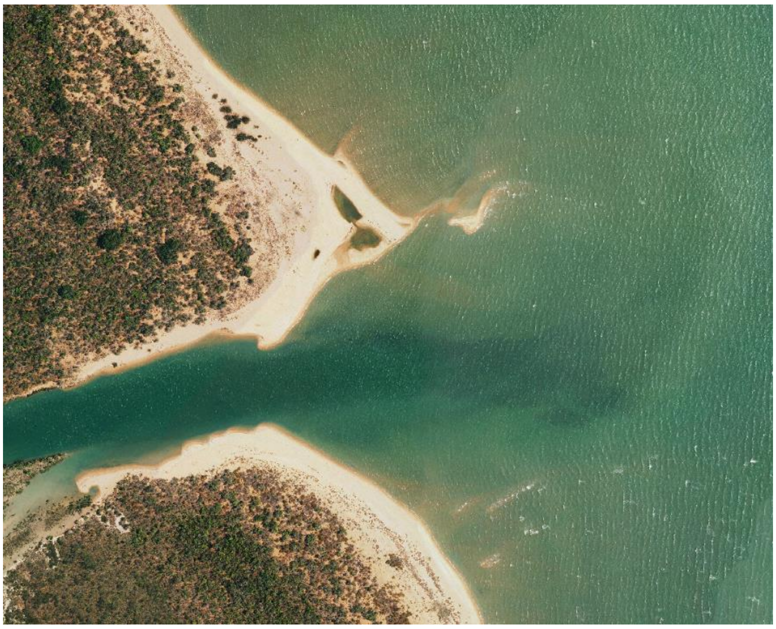


Figure 1 Aerial imagery obtained along the Gulf of Carpentaria

4.4 Elevation Model

The LiDAR dataset was used to create a Digital Elevation Model (DEM). The DEM has a spatial resolution of 1 metre and was critical for defining all natural feature ambulatory boundaries. The DEM enabled the MHWM and the MLWM for the intertidal zone, the MHWM along the tidal sections of the river, as well as the top of bank to be accurately plotted. The accuracy of the DEM is only as good as that of the LiDAR data collected, and it suffered in areas where the LiDAR observations were inhibited, such as dense mangroves. Alternative analysis methods and cadastral survey expertise were required in these cases, employing secondary coarser datasets and knowledge, such as the NIDEM and DEA water observation data.

The combination of imagery and the DEM to evaluate the representative land boundary placements was critical as it provided a visual context and a cost effective, efficient method to analysis a large area with an accuracy level at less than the decimetre.

A Relative Elevation Model (REM) was created at discrete sections along the non-tidal sections of the rivers. The REM provided a potential data-driven method for defining the top of bank boundaries as well as an alternative topography visualisation. The REM was created in relation to the river, where the model is created from interpolating points along the river. The model is an alternative approach to defining boundaries, but in this particular case was deemed to be an inappropriate method to accurately delineate the boundary.

4.5 Survey Plan Production

The purpose of the data collection and modelling is to aid the Licensed Surveyor in the production of a survey plan that is required for the grant of land and issue of title. Together with details about the locations and sizes of the subject parcels, the survey plan delineates the boundaries of the land claim. The survey plan's goal is to delineate the natural feature ambulatory boundaries and the measurements that correspond with them. Specifically, the MHWM and MLWM will be identified by their epoch-specific values. See Figure 2. Furthermore, aerial imagery underlying the survey boundaries is being considered to provide more context to the boundary extents.

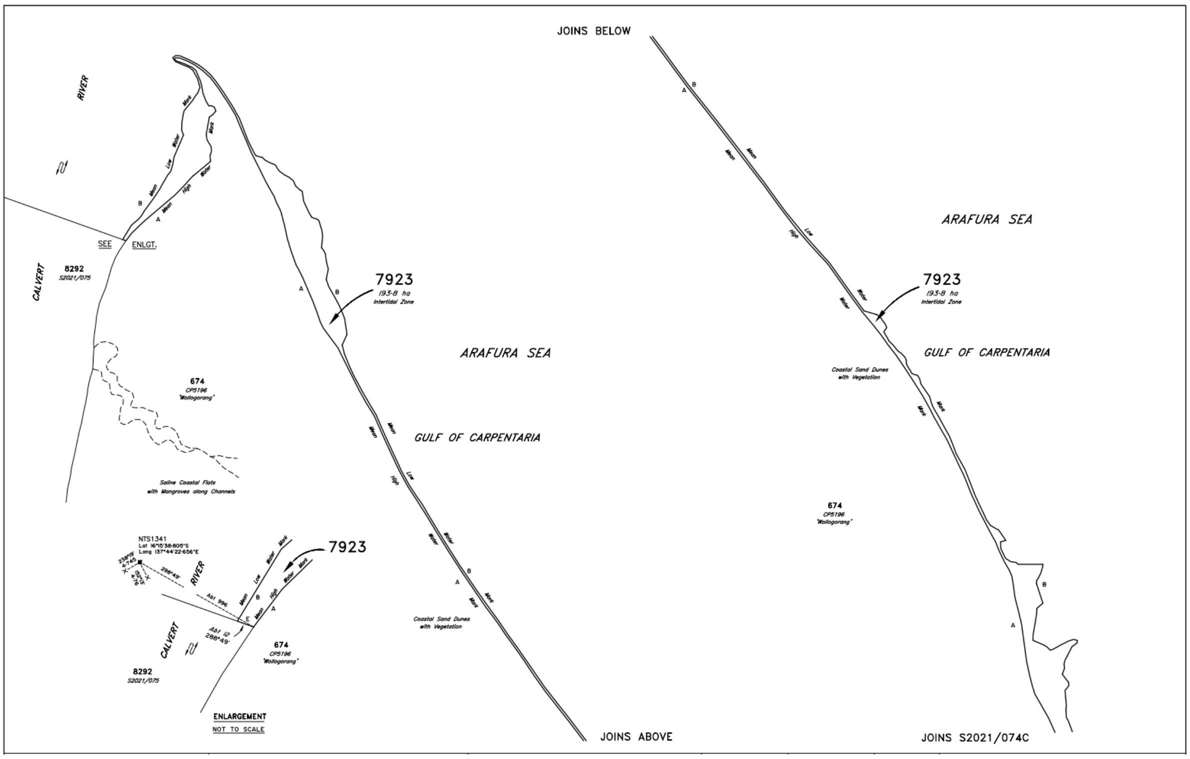


Figure 2 Preliminary Survey Plan - Wollogorang LC No.187

As a requirement, the survey plan is required to be submitted in a digital file format to be placed into the NT's Survey Plan Integration Cadastral Adjustment Database (SPICAD). Please note SPICAD is data repository and interface that manages the adjusted seamless parcel geometry, prior to being accessible to the users via the NTG's LIG digital cadastral database (DCDB) and Integrated Land Information System (ILIS). Currently, an '.acs' file is required to do this, which is an ASCII file. Due to the nature of the boundary delineation, an alternative file type, such as a shapefile or DXF, is required for the submission.

5. DEVELOPMENT OF PRINCPLES FOR NATURAL FEATURE AMBULATORY BOUNDARY DELINEATION

The nature of the project dictated the development of a set of principles to guide the Licensed Surveyor in their boundary determination process and to ultimately be accepted survey directions or practice within the NTA. The principles aim to:

- Establish guidelines for defining the land grant as per the Commissioner's recommendation.
- Interpret the Commissioner's recommendations through surveying terminology, as to provide survey and geospatial professionals with a sounder understanding of the requirements.
- Offer guidance on the surveying of intertidal zones as well as beds and banks of a river using multi-disciplinary techniques.

Key Principles		
General	Intertidal Zone	Beds and Banks of a River
• Review the Commissioner's report, ATM and survey tender documentation. • Review original land claim descriptions. • Seek advice from the stakeholder group or principal for clarification or interpretation of boundary locations. • Consideration / importance of adjacent cadastral boundaries. • Employ the most appropriate survey and geospatial techniques or use best available data to produce models that best represent the natural feature.	• Defined between the MHWM and the MLWM. • Understanding of relationship between datums for land, sea, and the ellipsoid. • Propagate differences in tidal plane values between tidal buoys. • Hydrographic survey data should be used as the primary source for intertidal zone determination. • Where rationalisation of the MHWM or MLWM occurs, a consistent approach should be used.	• The bed and bank is the area that contains and directs the normal flow of the river. • Tidal River ○ The boundary extends to the MHWM. ○ Same principles apply as intertidal zone. • Non-Tidal River ○ The boundary extends to the top of bank. ○ Consider using cross-sections to define the top of bank. ○ Where multiple banks exist, e.g. multiple channels or bars, careful consideration should be given.

Currently, the principles are provisional and undergo continuous refinement based on feedback from the survey industry and various stakeholders. This feedback has resulted in more comprehensive and clarified principles, bringing additional data considerations into focus for boundary delineation or verification. The overarching objective is to share the principles with other jurisdictional bodies and professionals for peer review before formalising them as a prescribed survey practice direction within the NTA.

The development of these principles brought to light the differences in the interpretation of the Commissioner's recommendations from survey, geospatial information, and legal perspectives. This has potential to significantly impact the land claim area and, consequently, the placement of boundaries for the land grant, as well as existing tenure rights adjacent to the land claims. This highlighted the importance of open communication, especially at the outset of the project and revealed the consequences of miscommunication and assumed understandings. In hindsight this should have been more thoroughly documented to formalise agreed interpretations, opinions, and outcomes; thus, providing a more efficient project outcome. As a result, the stakeholder working group is currently engaged in discussions regarding the resolution of these differing interpretations.

6. BOUNDARY DELINEATION

When the Licensed Surveyor is undertaking their boundary determination, existing tenure boundaries and the rights of adjacent landowners are considered before the delineation of the intertidal zone and the beds and banks boundaries. These considerations are important aspects for the cadastral survey and are items that were considered in the initial processes of determining the land claim extents and highlighted in detriment reports by the Commissioner.

6.1 Intertidal Zone Boundaries

The tidal plane values produced by the AHO define the intertidal zone boundaries, which are the areas between the MHWM and the MLWM.

The tidal plane values were plotted using a GIS software and performed by an experience geospatial information professional. The output was analysed to determine whether it was necessary to smooth, simplify, and/or rationalise the MHWM and the MLWM polyline. In cases where the produced line looped back or appeared to have a high sinuosity pattern, the MHWM and the MLWM was manually rationalised. Where rationalising of sections occurred, a consistent approach was used. For the MHWM, a rationalised polyline was manually created, connecting sections on the landward side of the sinuous line. For the MLWM, a rationalised polyline was manually created, connection sections on the seaward side of the sinuous line. See Figure 3.

At prominent points along the coastline where watercourses such as rivers, streams, outlets, and so on discharge into the ocean, essentially splitting the intertidal zone, the intertidal zone ends where the MHWM and the MLWM converged. This means that the intertidal zone is not a single continuous parcel along the coast, but rather a collection of parcels, representative of the natural feature.

The data-driven methodology for determining boundaries was inhibited at locations present with dense mangroves along the coast and along tidal sections of rivers. As a result, accurately defining the MHWM proved challenging. A comparison between imagery and other coarser datasets such as the National Intertidal Digital Elevation Model (https://www.dea.ga.gov.au/products/dea-intertidal-elevation) and Digital Earth Australia (https://www.dea.ga.gov.au) datasets were used to make the best-informed decision about the location of the boundaries, or at the Licensed Surveyors discretion an alternative feature, representative of the MHWM was chosen.

Figure 3 Intertidal zone boundaries (smoothed and rationalised)

6.2 Tidal River Boundaries (Beds and Banks)

For tidal sections of a river, the boundary is defined as the MHWM. Like the intertidal zone, MHWM is plotted based on tidal values.

Where subsidiary watercourses, not being the channels of the river, coalesce into the river channel, and where they do not form part of the recommended land grant, at the point of confluence, a baseline is drawn to connect the MHWM on either side of the top of bank.

Unless otherwise recommended for inclusions, islands/islets are excluded from the beds and banks claim.

6.3 Non-Tidal River Boundaries (Beds and Banks)

For non-tidal river sections, the boundary is the top of bank unless adjacent parcels boundaries are defined otherwise, such as to the centreline of the river. The top of bank determines the course of the river, even though than bank may be submerged at particular times, such as in flood. That is to say, the top of bank contains and directs the flow of the river.

The definition of the top of bank boundary is more difficult without an automated data driven approach, requiring multiple analysis techniques and is subjective to the Licensed Surveyors interpretation.

The DEM was used to generate cross-sectional profiles that highlight changes in topography, allowing for the top of the bank boundary to be defined. See Figure 4. A 3D scene view was also used, with a hillshade layer applied to improve visualisation and aid in the delineation of the top of the bank. These methods were generally successful in areas with clear discernible banks, while in other areas proved to be more difficult to apply due to changes in the topological characteristics of the river.

Where topological changes occurred, different approaches were used to define the boundary. In tightly braided river sections, the outer extent was defined as the boundary. Where attached bars occur, the boundary is defined around the channels of the attached bar because the bar itself is not considered to be part of the bed of the river. It is suggested that the remnant land is to be included in the land grant, with clear distinction that it does not form part of the bed of the river.

The REM provided an alternate method for contouring and visualising the top of the bank. Due to the morphology of the area, contouring a top of bank at a fixed value is a less-than-ideal method of definition when the boundary is defined as the 'top of bank', even when a REM is created over a discrete portion of the river. The relative contour value that correlates to the MHWM was plotted for the length of the non-tidal section of the river as a comparison for how well the delineation of the top of the bank matches the MHWM polyline, with consideration that the two are measured at different topological points. The resulting contour showed a consistent correlation between the MHWM and the top of bank, suggesting that the placement or determination of the top of bank is consistent with where the river contains and directs the flow of water.

Determining the top of the bank in intermittently flowing rivers can be difficult due to the limited presence or the absence of flowing water. In these cases, the DEM and hillshade layers, combined with aerial imagery along with cross-sectional information were used to discern river scarring, which aided in the top of bank determination. Where discernibility is more difficult, a more advantageous approach to the claimants (TOs) in defining boundaries was taken.

(a)

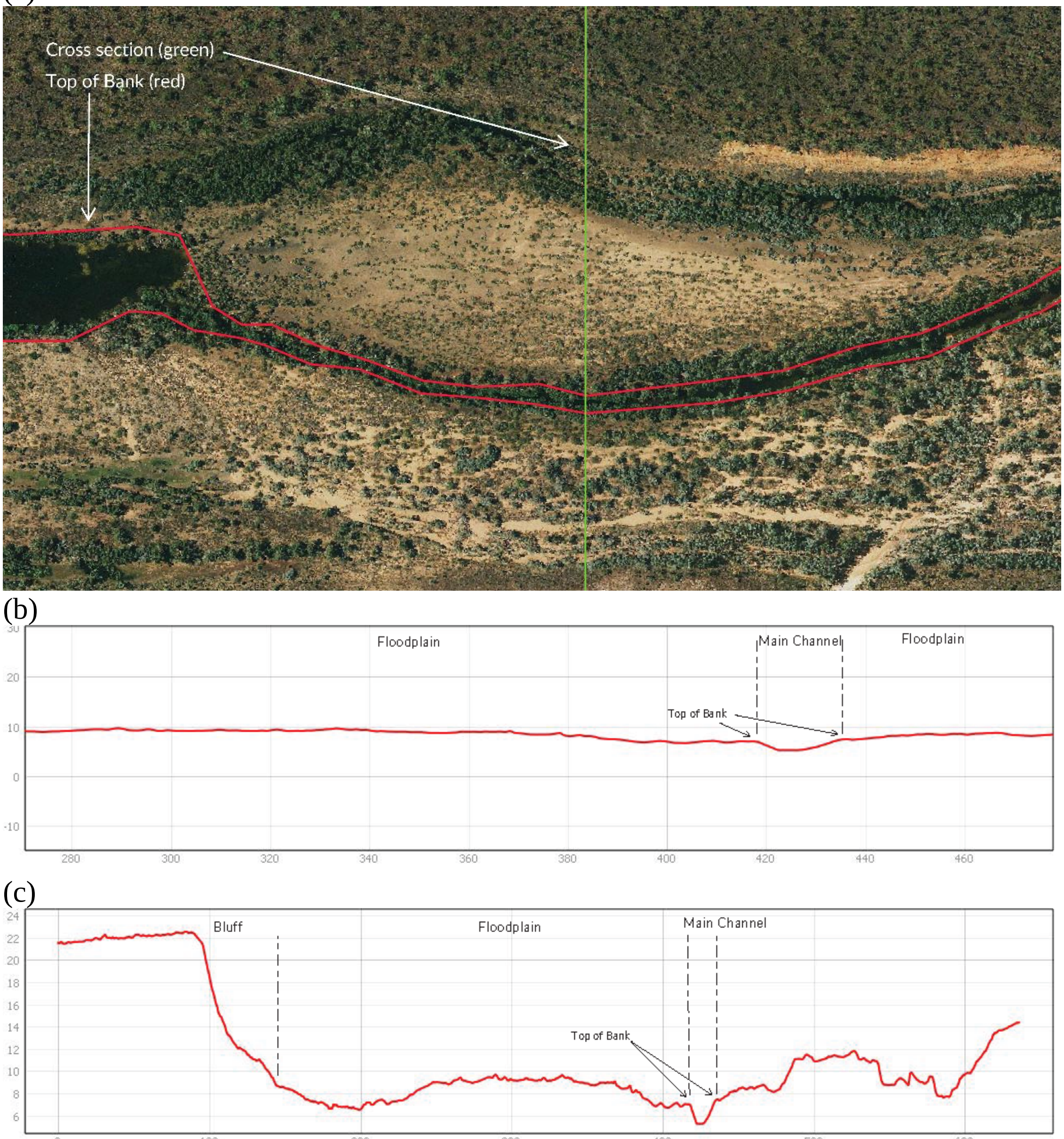


Figure 4 Non-tidal beds and banks boundaries. (a) Visual cross-section and boundaries, (b) same axis scale plot of cross section, and (c) exaggerated scale plot of cross-section

6.4 Other Boundary Considerations

It is anticipated the survey or geospatial interpretation and subsequent representation of the land claim boundaries, may deviate, or require clarification with respect to the Commissioner's recommended description of the land grant. For these situations, the Licensed Surveyor has or should determine the alternative boundary, ensure the alternative has been unambiguously described, and then refer the alternative to the stakeholder working group for their consideration and endorsement. An example case may be for a top of a bank that is indeterminate or not existent and the back of vegetation or edge of a cliff may be the most unambiguous, logical boundary definition.

Other instances are where islands, islets or particular river or estuarine system features are not explicitly included in the land for grant, they are still defined by the Licensed Surveyor, and may be recommended for inclusion as a pragmatic standpoint, with the caveat that the islands and islets are not considered to form part of the bed of the river or an intertidal zone.

7. ACCOMPLISHMENTS AND EXPECTATIONS

7.1 Accomplishments

– Formulation of provisional principles for natural feature ambulatory boundary determination.
– A framework for future intertidal and beds and banks surveys.
– Technical survey and geospatial data observations, processing, project deliverables and compliance with standards and practice.
– AHO, improved tidal modelling for the Gulf of Carpentaria.
– GA improved national datasets and modelling such as NIDEM.
– Reliable geospatial information for land management and administration of the subject land claim area.

7.2 Expectations and Key Outcomes yet to be met

– Preliminary draft survey plans for all land claims in the Gulf of Carpentaria region. Expected to be completed by June 2024.
– Digital data to be lodged in the correct format.
– Stakeholder endorsement of survey plans.
– Surveyor-General approval of survey plans.
– Official grant of and registration of title.

8. RECOMMENDATIONS AND CONCLUSION

As with any large-scale, unique project inevitably there will always be aspects that could have run more efficiently or where clearer communication could have been employed. With the involvement of multiple groups and professionals across many disciplines, predictably there will be varied levels of understanding and expertise, especially between land tenure, survey and geospatial data and modelling, and legal perspectives and including TOs, pastoralists and other stakeholder groups. It is important that all parties involved trust in the professional judgement of each other and can formulate and agree to a process from the outset. Transparency is paramount throughout the whole project to ensure deliverables and expectations can be met as well as providing explanations on data interpretation and informative decision-making processes. This is particularly important for stakeholders with limited understanding of spatial or scientific data.

Moving forwards, the engagement and communication process should aim for all stakeholders to agree with definitions and approaches before survey work is undertaken. While this was followed for this project, it was not entirely evident due to the nature and complexity of the project. The resultant delineation of cadastral boundaries did not meet stakeholder expectations, e.g. the intertidal zone being as small as eight metres wide, with expectations being that it would be far wider.

Communication breakdowns and disparities in expertise can be major obstacles in large-scale projects involving a diverse group of stakeholders and professionals. From the beginning of the project, trust and open communication are essential, especially when handling land tenure, surveying, geospatial data, legal issues, and a variety of stakeholder groups. Meeting expectations and elucidating data interpretations for individuals who are not well-versed in scientific information are ensured by transparency. To learn from past experiences where certain project outcomes may not have been immediately apparent, future engagements should prioritise consensus on definitions and approaches before surveys. This will emphasize the importance of clear communication and trust-building in such complex endeavours.

In conclusion, the delineation of land claim boundaries in the NTA represents another step forward in recognising and empowering the land rights of Aboriginal Australians. Numerous land grants were made possible by the ALRA’s enactment, with the current project standing out as a first-of-its-kind endeavour. This project differs from previous land surveys as it includes the intertidal zone and beds and banks of rivers.

In moving forward, the lessons learned from this project should serve as a foundation for future initiatives in natural feature ambulatory boundary delineation. The commitment to peer review and formalising the principles aims to contribute valuable insights and considerations to the broader field of cadastral surveying. Ultimately, the project exemplifies a harmonious blend of administrative and technical expertise to facilitate this type of land grant, recognising and empowering Aboriginal land ownership.

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Damon Whish-Wilson obtained a degree in Bachelor of Surveying and Spatial Sciences and Graduate Diploma in Land Surveying from the University of Tasmania in 2021 and 2022, respectively. He is currently under a professional training agreement to become a Licensed Surveyor.

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Rob Sarib obtained degree in Bachelor Applied Science – Survey and Mapping from Curtin University of Technology Western Australia in 1989. He also holds a Graduate Certificate in Public Sector Management received from the Flinders University of South Australia. Rob was registered to practice as a Licensed Surveyor in the Northern Territory, Australia in 1991. Since then, he has worked as a cadastral and geodetic surveyor, and a land survey administrator. Mr. Sarib has been an active member of the FIG since 2002, and is now Chair of the FIG Asia Pacific Capacity Development Network. He is presently the Chair of the Surveyors Board of Northern Territory; and member of the Inter-governmental Committee on Survey and Mapping – Australia.

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