ACT Heritage Council

BACKGROUND INFORMATION

Orroral Valley Tracking Station

(part Block 8, Rendezvous Creek)

At its meeting of 11 February 2016 the ACT Heritage Council decided that the Orroral Valley Tracking Station was eligible for registration.

The information contained in this report was considered by the ACT Heritage Council in assessing the nomination for the Orroral Valley Tracking Station against the heritage significance criteria outlined in s10 of the *Heritage Act 2004*.[1]

HISTORY

In considering the history of the Orroral Valley tracking Station, the ACT Heritage Council acknowledges that the Ngunnawal people are traditionally affiliated with the lands in the Canberra region within and beyond contemporary ACT borders. 'Orroral' could come from the Aboriginal word 'Urongal,' meaning, 'tomorrow,' indicated as such in sir Thomas L. Mitchell's 1834 map of the area. In this citation, 'Aboriginal community' refers to the Ngunnawal people and other Aboriginal groups within the ACT for whom places within the Canberra region are significant. These places attest to a rich history of Aboriginal occupation extending from 25, 000 years ago, as indicated by the Birrigai Rock Shelter, into the 19th century colonial period. They show that Aboriginal people continued living traditionally in the region through to the 1870s-80s. During the 19th century, traditional Aboriginal society in colonised areas suffered dramatic de-population and alienation from traditional land-based resources. In the Canberra region some important institutions such as intertribal gatherings were retained in some degree at least until the 1860s.

Australia was one of the first nations to take an interest in space activities when it participated in the British missile development program of the 1940s and 1950s. The Anglo-Australian joint project saw the Long Range Weapons Establishment (LRWE) created in 1947 with its testing range at Woomera, South Australia. By 1956, the United States (US) had installed satellite tracking facilities at Woomera, and by the 1960s it had become one of the most heavily used space launching facilities in the world (Egloff 1988; Fabricius 1995; Ramsay et. al 1995).

Australia played an important role in twentieth century tracking and communications. In 1960 the US and Australia signed an agreement under which Australia established and operated a number of tracking stations which would form part of worldwide networks under the control of the National Aeronautics and Space Administration, or NASA (Egloff 1988; Fabricius 1995; Ramsay et al 1995).

Three of these new tracking stations were located in the ACT, at Tennent, Paddys River, and Rendezvous Creek where they would be protected from radio interference (Gorman 2012: 23).

Three space tracking stations operated in the ACT by 1967:

[1] Minor corrections were made to this document in 2018 in the interests of maintaining accurate and up to date information. These corrections do not affect the decision made on 11 February 2016 (NI2016-74).

- Tidbinbilla Tracking Station (active) for DSN: Deep Space Network;
- Honeysuckle Creek Tracking Station (no longer active) for MSFN: Manned Spaceflight Network; and
- Orroral Valley Tracking Station (no longer active) for STADAN: the Space Tracking and Data Acquisition Network.

Orroral Valley Tracking Station was operational by October 1965 (Clark 2012: 15). ‘Orroral’ could come from the Aboriginal word ‘Urongal,’ meaning, ‘tomorrow,’ indicated as such in Sir Thomas L. Mitchell’s 1834 map of the area. The tracking station encompassed about 40 acres and was constructed with a powerhouse, canteen, water supply, mechanical workshops and operations building. Antennae and buildings were situated to minimise interference with each other with some levelling of the site was required before construction (Ramsay et al 1995: 8; Gorman 2012: 24).

The Orroral Valley Tracking Station operated until 1985, supporting the large number of scientific satellites that helped develop and support the manned space flight program and other missions. In its later years it also communicated with the scientific packages left on the moon by the Apollo astronauts, and tracked manned spacecraft for the Apollo-Soyuz, and the Space Shuttle programs (Clark 2012: 1).

The Apollo-Soyuz Test Project was a joint initiative between the US and Russia. NASA astronauts were sent in an Apollo Command and Service Module to meet Russian cosmonauts in a Soyuz capsule. The aim of the mission was to demonstrate that two dissimilar spacecraft could dock in orbit, and was fulfilled when a co-designed, American built docking module completed the procedure (NASA 2012).

NASA’s Space Shuttle program consisted of the spacecraft Columbia, Challenger, Discovery, Atlantis and Endeavour and flew 135 missions between 1981 and 2011. The Space Shuttle program helped build the International Space Station, carried people into orbit for decades and launched, recovered, and repaired satellites (NASA 2015a).

Orroral Valley Tracking Station was also involved with the Weapons Research Establishment Satellite (Wresat) project. Wresat was the first Australian designed, built, launched, and tracked satellite. In 1967 Australia became only the third country in the world to launch and track its own satellite from its own country. The satellite was launched in Woomera, and tracked by the Orroral Valley Tracking Station (Philip Clark personal communication 19 June 2015). Launched on November 29 1967, Wresat was integrated into the SPARTA project: a tripartite program between the US, Australia and Britain researching the physical effects on warheads of high speed re-entry into the Earth’s atmosphere (Australian Space Research Institute 2012).

The main function of Orroral Valley Tracking Station was to track and control un-manned scientific satellites. It was the largest tracking station in the southern hemisphere and a member of STADAN (Satellite Tracking and Data Acquisition Network), the largest space tracking network in the world. It had a workforce of about 200 people and by 1966 was capable of tracking up to five satellites independently and simultaneously. In 1974, when a nine metre dish antenna was added to the facility the number of satellites that could be tracked increased to six, and with the addition of a Smithsonian Astrophysical Observatory laser system in 1975, as many as seven satellites could be tracked at once (Clark 2012: viii – ix).

The Deep Space Network

The Deep Space Network – or DSN – is NASA’s international array of radio antennae that supports interplanetary spacecraft missions, and some that orbit Earth. It originated in 1958 when NASA was formed and took over plans to develop a deep space observation network already in progress by other agencies in the US (Gorman 2012: 6). The DSN also provides radar and radio astronomy observations that aid in understanding of the solar system and the larger universe. The DSN consists of three facilities spaced equidistant from each other – approximately 120 degrees apart in longitude – around the world. These sites are at Goldstone, near Barstow, California; near Madrid, Spain; and Tidbinbilla, Canberra, Australia (NASA 2015b)

For 20 years, the Orroral Valley Tracking Station tracked satellites 24 hours a day every day of the year. At a time when the Deep Space Stations of the US were receiving data at less than 100 bits per second, Orroral Valley Tracking Station was receiving and processing data from spacecraft at up to 128,000 bits per second (Clark 2012: 1).

Minitrack, STADAN, and Orroral Valley Tracking Station

Tracking stations are the ground segment of a satellite communication system. For the control centre to stay in contact with a satellite, the satellite must be linked to a network of ground stations across the planet, as a spacecraft in Low Earth Orbit circles the Earth approximately every 85 minutes up to days and is only in reach of any station for a short time. Tracking stations communicate with a satellite in orbit, providing a connection between the satellite and its control centre. A tracking station *acquires* a satellite's orbital location; acquisition refers to the moment and action of first receiving a radio signal from a spacecraft. A tracking station also *tracks* a satellite's orbital evolution through time. It may also send commands to spacecraft and receive data. (Clark 2012: viii; Gorman 2012: 2).

In order to launch its first satellite in the late 1950s (Explorer 1), the US needed a reliable means of tracking it. While at that time the US had an optical tracking system, this system only worked when skies were clear, and it could not receive data from a satellite. To overcome these deficiencies, US scientists and engineers looked for a solution that would enable them to track a satellite in all weather conditions, and to retrieve data from it. Many of the systems that had been proposed up to this time required a large, heavy, complex transmitter on the satellite to achieve the required result and the first satellites were not able to carry such a load. Eventually a system was devised that required a minimum weight transmitter on the satellite. The system on the ground would be able to track this small transmitter with considerable accuracy and at the same time receive data. The name of the minimum weight system was condensed to 'Minitrack' (Clark 2012: 8).

A number of Minitrack stations would be required to track a satellite and determine its orbit. Australia was in an advantageous position such that first orbit of nearly all satellites launched from the Cape Canaveral site in Florida (US), would pass over Australia. This was important as it enabled the determination of orbital insertion and the actual orbit achieved. A Minitrack system was subsequently located in Woomera (Clark 2012: 8-10).[2]

Associated with the Minitrack antenna array was the Minitrack Optical Tracking System (MOTS). This was an astrographic camera that could photograph a spacecraft which was illuminated by the sun at certain intervals. The position of the spacecraft was then calculated by assessing the stars in the background of the photograph. A MOTS was part of the Minitrack system at Woomera, and subsequently Orroral Valley Tracking Station (Gorman 2012: 5).

The Manned Spaceflight Network

The Manned Spaceflight Network – or MSFN – consisted of 26m antennae at Goldstone, Madrid, and Honeysuckle Creek, ACT Australia. Honeysuckle Creek Tracking Station received the imagery from the Apollo 11 mission in 1969 that were distributed to the world (Gorman 2012: 7). The MSFN was mission oriented, and MSFN stations did not generally track a number of different satellites routinely, but were dedicated to manned space missions (Clark 2012: 1).

Although the DSN and MSFN programs have generated considerable renown, the unmanned scientific spacecraft, tracked by STADAN, were responsible for the safety of the manned spaceflights by detecting dangerous radiation and other hazards in space. They also provided the foundation for the development and improvement of the space communications systems that were first used in support of space exploration and that are now used in many ways today (Clark 2012: 1).

Explorer 1 was launched into orbit on 31 January 1958 and was tracked by the Minitrack network. In October that year, the US Government formed NASA to carry out satellite launches and tracking. The US was also beginning to launch deep space probes, and needed a tracking, telemetry, and command network which could track satellites 24

[2] The Minitrack system is an angle measuring interferometer system. It measures the difference in time of the arrival of a radio signal transmitted from the spacecraft by using fixed antennae on the ground. With most of the spacecraft, the carrier signal of the telemetry transmitter was also used as the Minitrack tracking signal. The Minitrack antennae are separated by fixed and accurately known distances, and the system can measure the difference in time that the satellite signal arrives at the various antennae. From this it is possible to calculate the angle of the satellite in relation to the antennae (Coates cited in Clark 2012: 9).

Minitrack requires two sets of antennae, one set has an East-West baseline and the other has a North-South baseline. The antennae used to most accurately determine the spacecraft angles are the most widely separated and the largest. They are called the 'fine' antennae. However these antennae on their own cannot properly determine the spacecraft angle because they have ambiguities and they need to work in conjunction with other antennae that take away such errors. These other antennae are called the ambiguity antennae, and all are combined in various ways to give coarse, medium, and fine angle resolutions (Coates cited in Clark 2012: 9).

hours a day (Clark 2012: 10). As such, the Minitrack stations needed to be upgraded and a new network of stations established.

The new network emerged, and became known as STADAN (the Satellite Tracking and Data Acquisition Network). STADAN stations used a form of 'YAGI' antenna called SATAN (Satellite Automatic Tracking Antenna Network) and SCAMP (Satellite Command Antenna on Medium Pedestals) at 136 and 400 MHz to accommodate the higher rates of data (although Orroral did not have SCAMP). Minitrack was upgraded in some cases and eventually replaced with new SATAN arrays, although this did not occur at Orroral (Philip Clark pers. comm 5 March 2018; NASA 2015c).

STADAN tracked many unmanned scientific satellites that were mostly in Earth's orbit. The orbits of these spacecraft ranged from circular and fairly close to the Earth, to highly elliptical, moving out to distances even further than the moon. Its role in STADAN meant the equipment at Orroral Valley Tracking Station had to be re-configured after each satellite pass in time for the next one. This had to be done on multiple systems some 40 or more times every day, often with as little as 10 minutes or less from the end of one pass to the beginning of the next (Clark 2012: 3).

Orbiting Geophysical Observatory Project (OGO)

The OGO project aimed to study the Earth's magnetic field, and also attempted to include multiple experiments on one spacecraft, a change from the smaller, more focused Explorer satellites (Clark 2012: 207). OGO spacecraft and interfaces with experiments were designed to be standardized, and the OGO work laid the groundwork for future standardised spacecraft designs. The standardised spacecraft approach has remained a recurring theme at NASA (Clarke 2012: 207).

The scientific satellites were initially a series of orbiting observatories, or telescopes in space; these were not always single satellites, but constellations of satellites. For example, the Orbiting Geophysical Observatory (OGO), supported by the STADAN network, consisted of 7 satellites, with four in highly elliptical orbits, and three in near-Earth polar orbits (Gorman 2012: 9). The Orroral Valley Tracking Station tracked satellites as part of STADAN including the Orbiting Geophysical Observatory, Orbiting Astronomical Observatory, and the Orbiting Solar Observatory.

In addition to supporting scientific satellites in Earth's orbit, STADAN was also used for crewed spaceflight, and other projects (GSCF 1974:1-1 cited in Gorman 2012). The MSFN closed in 1972 (except for a brief reactivation in late 1973 to track the Skylab program), and from 1974 STADAN took over the role of manned space tracking and was renamed as the Spaceflight Tracking and Data Network. By the early 1980s most STADAN stations were no longer in use (Clark 2012).

In 1966 the Minitrack station from Woomera, including the MOTS camera, was moved to Orroral Valley Tracking Station. A Baker Nunn camera – one of 12 deployed around the world circa 1957 – which could photograph satellites in space to locate their position, was transferred from Woomera to Orroral Valley Tracking Station in 1975 (Gorman 2012). Later, in around 1981, a 6 metre S-Band uplink antenna was also added (Philip Clark pers. comm 5 March 2018).

Equipment at Orroral Valley Tracking Station was continually upgraded. In the 1970's the 26m antenna was modified to receive higher frequency S-band transmissions, and in 1974 a 9m antenna, also designed for receiving S band, was added (Gorman 2012).

The 1960 agreement between the Australian and US Governments specified that in the event of stations no longer being required by NASA they would be returned to their natural state. However upon closure of the Orroral Valley Tracking Station in 1985, the Australian Government requested that the structures remain for future use. NASA removed most of the equipment, consistent with the provisions of the agreement. Following the station's closure the 26 m antenna was moved to Tasmania for use in radio astronomy research (Gorman 2012; Clark 2012).

While Orroral Valley Tracking Station, and before it, in 1981, Honeysuckle Creek Tracking Station, were closed, Tidbinbilla Tracking Station remains open and operational and continues to receive and track data for the Deep Space Network, continuing NASA's connection with the ACT, and the ACT's involvement in international space exploration. Most recently, in July 2015, Tidbinbilla Tracking Station (or Canberra Deep Space Communication Complex), received some of the first images of Pluto as part of NASA's New Horizons mission.

Thomas Reid, MBE, managed the Orroral Valley Tracking Station for a time. He moved to Canberra in 1964 to become the first director at Orroral Valley where he remained until 1967 when he moved to Honeysuckle Creek Tracking Station and was the director there during the first moon landing. In 1970 he became director of the two NASA DSN stations located at Tidbinbilla. For his contribution to the manned flight program he was awarded an MBE in the New Year Honours List in 1970. He was awarded the NASA Public Service Medal in 1975, and actually presented with it by visiting Vice President Dan Quayle in April 1989 (Parliament of Australia 2010).

In his book *Uplink-Downlink: A History of the Deep Space Network from 1957* Doug Mudgway says of Tom Reid:

> *His crisp management style and penchant for clear lines of authority, particularly in his relations with JPL (Jet Propulsion Laboratory) and NASA personnel, made a visit to 'his' complex a memorable experience for many Americans. He ran the stations in a disciplined, formally organized way that attracted and retained the best technical staff available. As a direct result of their teamwork and his leadership, the DSN station at Tidbinbilla played a critical role in all of NASA's deep space missions in the years 1970-1988* (Mudgway 2001).

Orbiting Solar Observatory (OSO) and Orbiting Astronomical Observatory (OAO)

From 1962, eight OSO satellites launched into orbit with the aim of observing the Sun's wavelengths and solar flares. OSO satellites provided the first close look at the Sun in important regions of the spectrum that could not be observed by ground-based observation methods. The first OSO satellite measured electromagnetic radiation from the Sun over time in ultraviolet, X-ray, and gamma ray regions of the spectrum (Clark 2012: 209).

OAO was designed to explore the sky in both the visual and ultraviolet regions of the spectrum, enabling the compilation of the first complete ultraviolet map of the sky, creating a catalogue for use by astronomers (Clark 2012: 208).

DESCRIPTION

Primary buildings and antennae at the Orroral Valley Tracking Station are no longer extant, but can be seen at images 2 and 3. These were:

<u>Operations area</u>

The operations building controlled the antennae, coordinated all tracking operations, and received data. A main equipment room was beside building with a view of the 26m dish and had a tiled floor that could be easily raised in order to service the extensive cables underneath (Gorman 2012: 28). It was a brick, square shaped (46.4m by 41.8m), single storey building, with a central landscaped courtyard (Neild et al 1992: 5).

<u>Facilities area</u>

This housed a series of workshops for use in vehicle maintenance, stores, mechanical repairs and carpentry. It was a substantial brick structure with large metal fascia and no external columns, unlike the design of the other buildings on site (Neild et al 1992: 8).

<u>Canteen</u>

Built during 1969, this was a brick building with metal deck roof, vinyl tiles in the dining room and tiles in the cooking and preparation areas (Neild et al 1992: 4).

<u>Minitrack building, MOTS and antenna field</u>

The design of the Minitrack building was similar to the other main buildings at the site, although it was smaller than the operations building. The Minitrack building was associated with the antenna field and a MOTS camera, moved from the Woomera facility. The layout of a Minitrack array can be seen at Image 4.

<u>Baker Nunn Camera mount</u> (see Image 5)

The Baker-Nunn Camera was moved from Woomera to Orroral Valley Tracking Station in 1975, where it remained until the station was closed. The camera worked by alternately tracking a satellite and then the star background, photographing them using high speed Kodak film, with an exact time printed on each exposure. A satellite's position could then be determined by comparing it with the star field. The footings were triangular and situated near the Minitrack array (ACT Government n.d.)

<u>26 metre dish (main antenna) and the antenna transmitter building</u> (see Image 6)

The main antenna was a paraboloid antenna or receiving dish. It was used to track satellites and receive data from them. The design was used in a number of significant tracking stations and observatories around the world. It was acquired by the University of Tasmania when the station closed in 1985 (Gorman 2012: 29, 30)

A small brick transmitter building was located immediately under the antenna. The antenna was oriented exactly due north and particular care was taken with the design of its footings to prevent settlement and foundation movement. For example, bore holes were dug prior to construction for geotechnical examination.

<u>9 metre dish and collimation building</u>

The 9 m antenna was a USB or Unified S-Band system, developed for the Apollo program, which could carry out tracking, telemetry, command, television and air-to-ground voice simultaneously (Gorman 2012: 31).

SATAN array

Two SATAN antennae were located inside the tracking station for receiving (downlink); a further two dedicated to sending commands (uplink) were located in the foothills to the south (see the SATAN command antennae near the access road in Image 3. The SATAN arrays were aimed at complementing the data acquisition and command functions of the big dishes at STADAN stations (Gorman 2012: 30)

Physical condition and integrity

After 1992, the buildings at Orroral Valley Tracking Station were removed. What remains is mostly concrete, bricks, and in some cases, original tiles on floor surfaces including green tiles from the ablution blocks, and grey flooring tiles in places. Although the buildings and antennae at Orroral Valley Tracking Station were removed, foundations are still present, with the layout of the place strongly evident in the landscape, offering strong interpretive value (see Images 7 and 8). In addition, former internal circulation roads remain intact, as do kerbs and gutters where constructed.

In 2012, Flinders University completed a magnetometer survey of the site, and detected multiple sub-surface anomalies indicating the location of multiple items and facilities in use during the lifespan of the Orroral Valley Tracking Station. Anomalies included the location of sub-surface infrastructure, cabling networks, and possible locations of burial pits relating to the demolition of the site (Gorman 2012: 65).

Grey tiles remain at the operations building, the canteen, and SATAN command antennae. Many remain in their original place, but some are deteriorating with cracked and/or crumbling edges. Where tiles have vanished, differentially weathered borders are frequently evident (Gorman 2012: 51).

Minitrack features which remain include the operations building footing and the pylons for the antenna array (see Image 9). The antennae had been supported on metal pipes within the pylons; these were mounted by a screw plates to adjust height. In most instances, the pipe had been shorn off at varying heights; however, several of these screw plates remain intact (Gorman 2012: 53).

The Minitrack array is distinctive as the remains are a series of concrete columns, among the tallest features present in the mostly-flat tracking station. Their pattern is discernible, although due to the slope of the ground it is not possible to see the entire array at once. The triangular Baker-Nunn mount also stands out among the mostly rectangular features of the surface footings. All pylons appear to be present (Gorman 2012: 53).

Parts of the Minitrack facility were acquired by the National Museum of Australia (Canberra) in the early 1980s. The National Museum also has numerous manuals and other documents relating to the operation of the station (Gorman 2012: 38).

A variety mature exotic trees remain from the occupied phase including cypress (*Cupressaceae sp*), Lombardy poplars (*Poplus nigra*) and silver birch (*Betula pendula* – see Image 10). The landscape setting acts to define the site and creates an abrupt transition between the former tracking station site and the cleared pastoral remains of the valley. Recreational facilities, including picnic tables and barbeques have been installed, and interpretation panels are located at points throughout the complex.

SITE PLAN

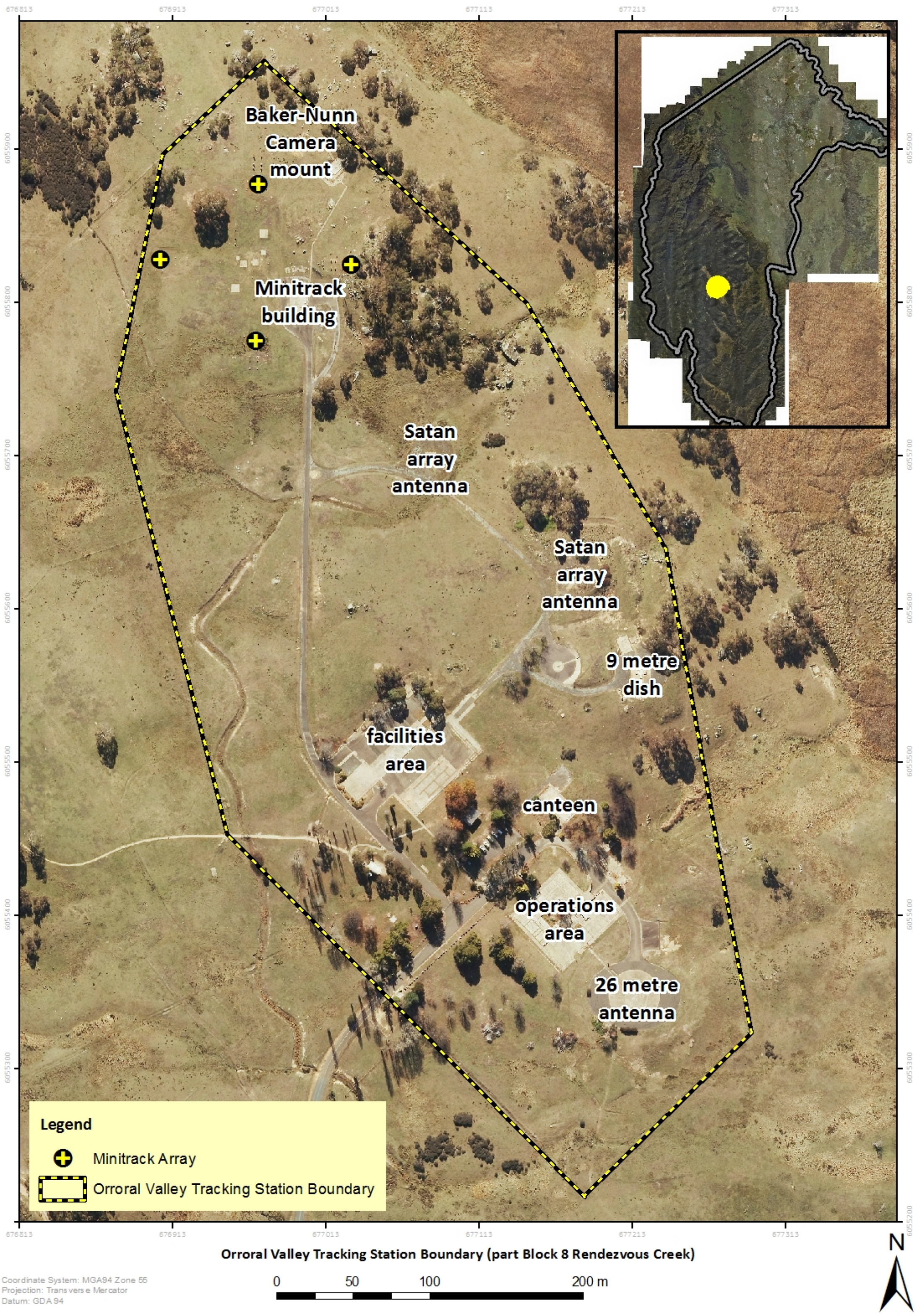
Baker-Nunn Camera mount
Minitrack building
Satan array antenna
Satan array antenna
9 metre dish
facilities area
canteen
operations area
26 metre antenna
Legend
Minitrack Array
Orroral Valley Tracking Station Boundary
Orroral Valley Tracking Station Boundary (part Block 8 Rendezvous Creek)
Coordinate System: MGA94 Zone 55
Projection: Transverse Mercator
Datum: GDA 94
0
50
100
200 m
N

Image 1 Site Boundary Orroral Valley tracking Station

IMAGES

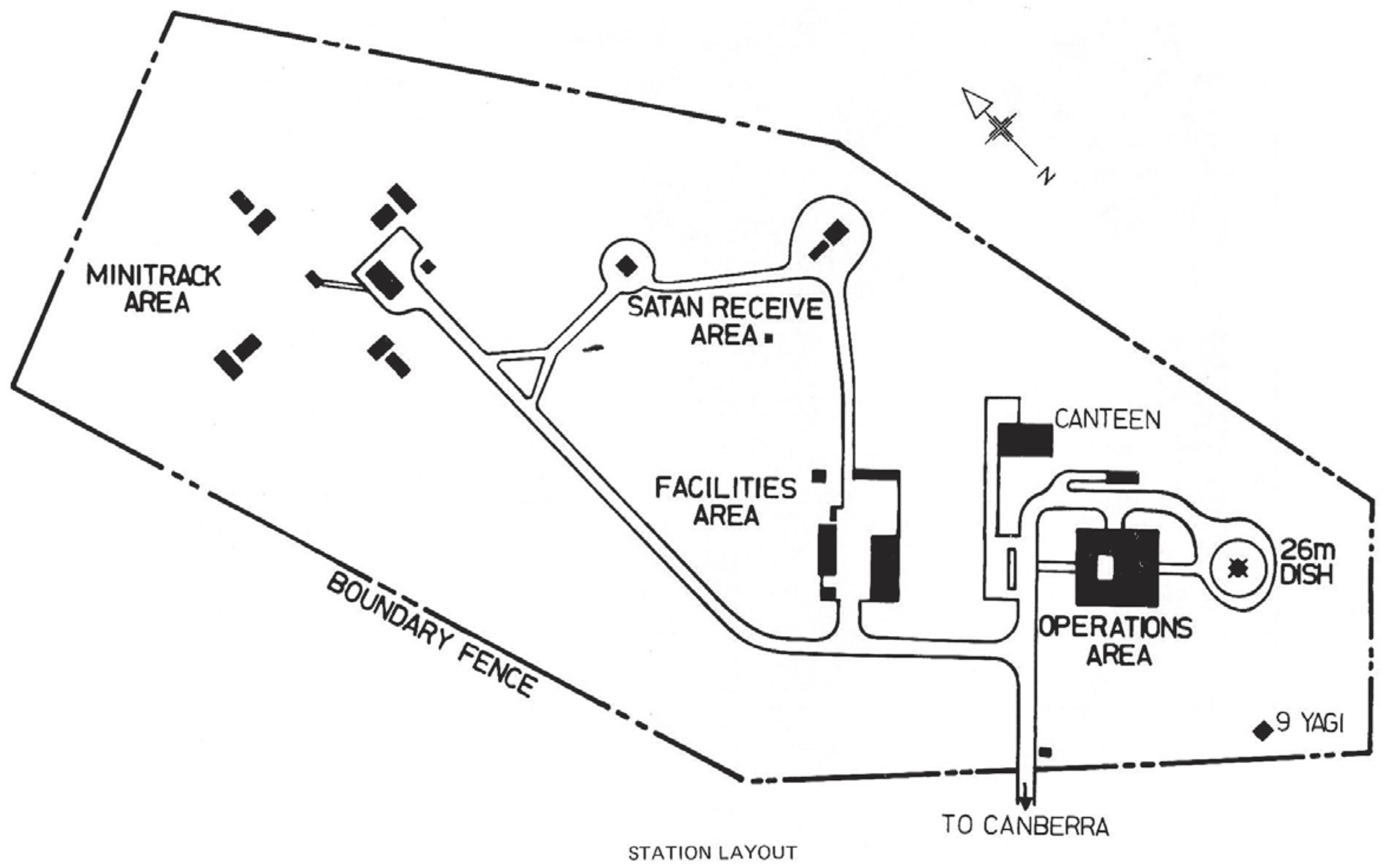

Image 2 Orroral Valley Tracking Station Layout 1965 (Clark 2012).

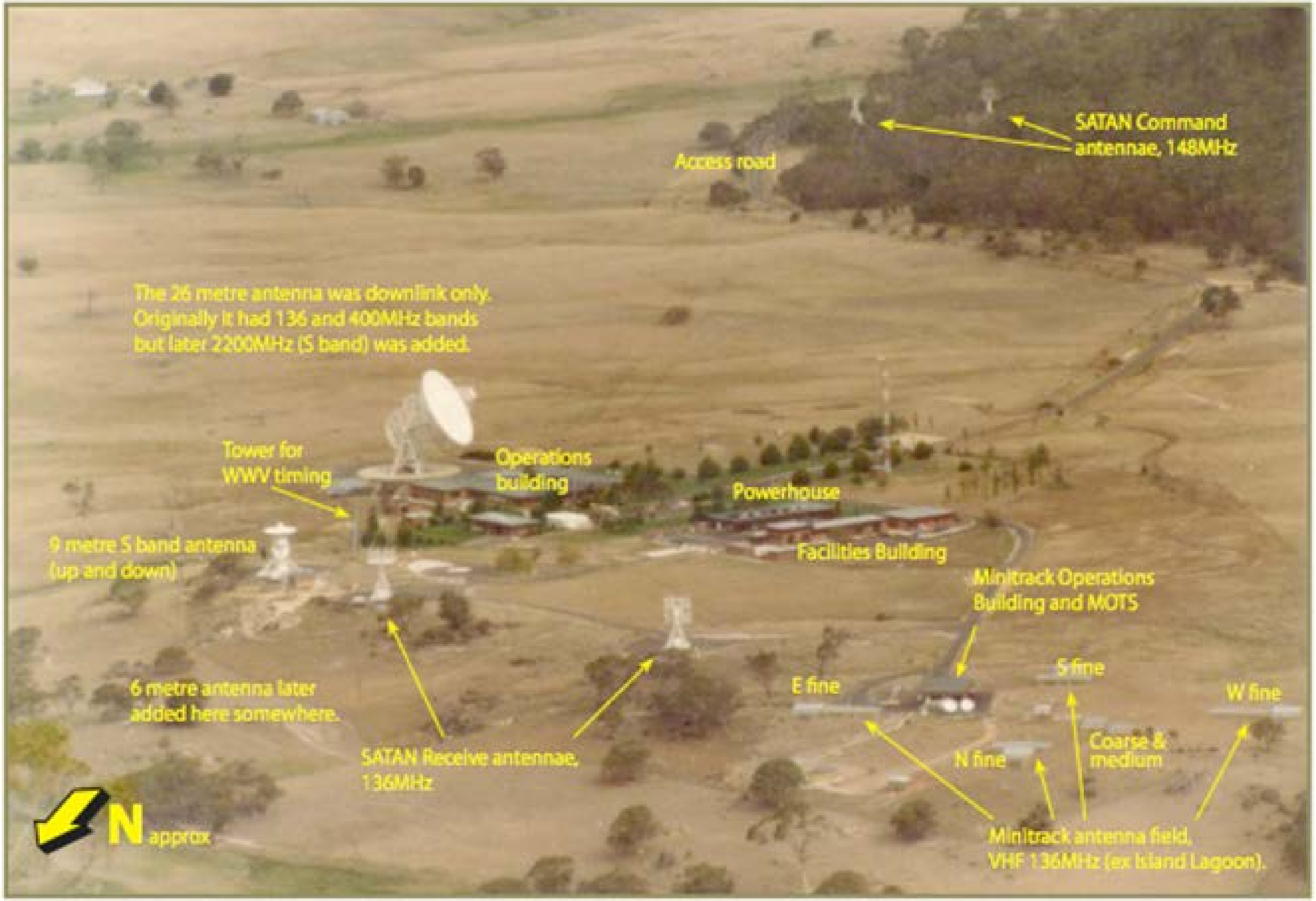

Image 3 Orroral Valley Tracking Station circa 1981 (MacKellar cited in Gorman 2012).

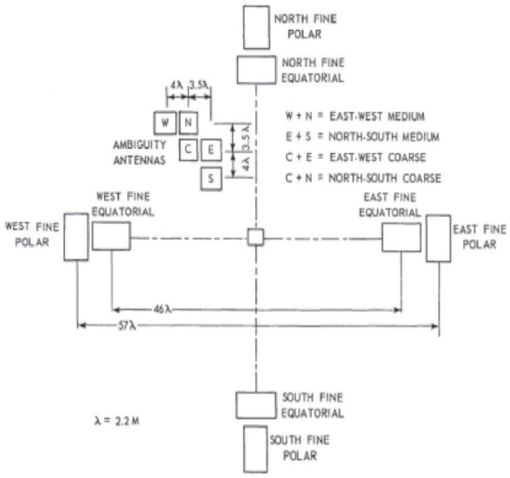

Image 4 A Mintrack array (Clark 2012)

Image 5 Baker-Nunn Camera mount (Gorman 2012)

Image 6 26m Dish at Orroral Valley Tracking Station in the 1960s (Gorman 2012)

Image 7 Platform of dismantled operations area (ACT Heritage 2015).

Image 8 Foundations for 26m dish (ACT Heritage 2015)

Image 9 Baker-Nunn Camera Mount (Gorman 2012)

Image 10 Exotic landscaping Orroral Valley Tracking Station (ACT Heritage 2015)

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