

## **100 Years of National Topographic Mapping Conference**

Australia's Role in the Mapping of Papua New Guinea:

from colonial outpost to independent nation

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### **Abstract:**

In 1906 Britain passed control of the Territory of Papua to Australia and in 1914, at the start of World War 1 (WWI), the previously German Territory of New Guinea came under Australian control. At the end of WWI, in 1920, Australia assumed administrative control over what is now Papua New Guinea. At the end of World War 2 (WWII), after the Japanese occupation of a large part of PNG during the war, the whole of PNG came under Australian control until PNG became an Independent nation in 1975.

During this period from 1906 to 1975, Australians had responsibility for the surveying and mapping of the whole country. Until the start of WWII the country was virtually unmapped and the efforts of our military forces were considerably hindered by poor mapping through the Kokoda campaign and beyond.

By 1980 (5 years after independence) Australia had completed the 100,000 mapping series for the whole country, which was now better mapped than the Australian mainland.

This paper will explore the role of Australia in the surveying and mapping of PNG from the 1900's through to the present day. The paper will highlight the efforts of both military and civilian cartographers in mapping one of the most inhospitable and inaccessible countries on the planet.

## **Introduction**

As the scope of this paper is to cover 100 years of mapping from an Australian perspective it is some convenience that Australia's "official" presence in what is now Papua New Guinea commenced in 1906, some 105 years from the date of writing. From a mapping perspective not much happened in the first 40 years of Australian presence in PNG, with WWII providing a focus for some serious attempts at mapping areas of conflict with the Japanese. Again after WWII a hiatus developed until the early 1960's but then much happened in a short timeframe with complete mapping of the whole of PNG at 1:100 000 completed by the mid 1980's, shortly after PNG became an independent nation in 1975. The story of the Australian involvement in the mapping of PNG is very much an untold story of courage, inventiveness and pure perseverance that deserves to be told.

## **New Guinea History to 1906**

The most definitive published work on the history of mapping and surveying in PNG is the monumental "Mastamak: The Land Surveyors of Papua New Guinea", by James Sinclair, published in 2001(Sinclair 2001). This book covers the exploration, surveying and mapping from the earliest known records through to Independence in 1975. This early history is but a very brief summary extracted mostly from this work.

By the late 1880's the island of New Guinea had been circumnavigated and the coast mapped by a number Dutch, German and British explorers. British Royal Naval Vessels had charted most of the coast by 1880. Notable amongst these is the work of Captain Owen Stanley from 1846 to 1850 and the work of Captain John Moresby in 1873-4. Moresby was the first to explore and map the North Coast of New Guinea. The Owen Stanley range and the present day Capital of PNG, Port Moresby, are suitable monuments to these early explorers.

At the turn of the 18<sup>th</sup> century the island of New Guinea had been colonised by the British, German and Dutch. Western New Guinea was claimed and administered by the Dutch who would maintain that control until the mid 1970's when Indonesia took control of what is now Irian Jaya. The British had proclaimed a Protectorate over Papua, the South Eastern portion of the island, and Germany had claimed the North Eastern portion of the island as German New Guinea.

In 1906 the British passed control of Papua to the new Australian Government (Federation of Australia was in 1901). John Hubert Plunkett Murray became the First Australian Lieutenant Governor of Papua in 1907 and served in that role until his death in 1940. According to

Sinclair's account "the work of government surveyors during the long reign of Sir Hubert Murray was, with few exceptions, largely routine: surveys of plantations and mining leases, town allotments, mission stations, road alignments and the like. Most of the exploration work was done by patrol officers (kiaps) and magistrates, very few of whom had any surveying skills and who produced maps that were usually inaccurate and approximate." (Sinclair 2001)(p. 69)

In 1914 at the outbreak of WWI Australia took control of New Guinea from the Germans and the Territory was managed by various Australian Military officers for 7 years until December 1920 when New Guinea became the Mandated Territory of New Guinea under Australian civil administration. Sinclair notes that "exploration in German New Guinea was done in the main by scientists and missionaries ... whilst the leaders of expeditions in German New Guinea seldom had professional surveying qualifications, they were often skilled in practical surveying and cartography and produced maps that were generally more reliable than those produced by Papuan officers." (Sinclair 2001)(p. 93)

Sinclair also notes in respect to the mapping of the coastline of New Guinea "that little hydrographical work was done by the Germans, with charts produced only of major stations and trading points and principal sea routes". (Sinclair 2001) (p. 100)

A paper by Robert Linke (Linke 2006) presented at the FIG congress in 2006 provides some more detail on the efforts by Germans in the surveying and mapping of New Guinea.

In the Mandated Territory, the Department of Lands, Surveys, Mines and Forest came into being in the early 1920's but was very modestly resourced. In the late 1920's the department expanded its capabilities in response to the developments on the Morobe goldfields, near present day Lae. Thus mapping work in the late 20's through to the 1940's was fairly well confined to areas where development was related to economic factors such as gold mining and oil exploration. Thus the area around Lae, including the Markham River valley, Bulolo, Salamaua, Wau and the Edie goldfields received considerable surveying and mapping attention. Contrastingly Papua was seen as "the down at heels" relation of the Mandated Territory, suffering through the great depressions in the early 1930's with little effort on any real surveying and mapping work through this period. The exception to this was the work on Oil exploration, mostly in the Gulf of Papua and carried out by surveyors working for major oil companies. Sinclair devotes large portions of his book to the work of the Oil company surveyors both pre and post war but again the mapping outcomes from this work was very limited in scope and geographic coverage.

## **Geography**

H.A. Johnson's personal experience in PNG in the 1950s and 60s gives an introduction to what lay ahead for the beaconing parties. He wrote:-

“Papua New Guinea lies between the latitude band of 2 to 11 degrees south and generally receives more than 100 inches of rain annually. Such rainfall has created dense tropical vegetation over most of the land, with great river swamps and deltas. The country is geologically young and unbelievably rough – Mt. Wilhelm, the highest peak stands at 14,800 feet. Many other mountains along the spinal ranges are over 13,000 feet and are mostly interconnected with ridges and spurs so steep and knife-edged it would seem that only a mantle of vegetation holds them in place. At times of continuous torrential rain, rock falls and mud slides are common. The few vehicular roads, many of them only suitable for 4WD's, often become blocked and bridges can be washed away. From the air, the lower slopes that lead to the main ranges look deceptively smooth with accessible grades, but on the ground the reality becomes a fascinating and challenging new world of a silent, dripping, half-lit tangle of slippery roots, spiny vines and bushes, with many buttressed trees festooned in moss. Progress through this labyrinth is difficult and frustrating, as often long steep climbs are negated by descents of similar magnitude before the next ascent begins. Climbing out of the heat and humidity of the rain-forest, and leading up to 11,000 feet, the vegetation and terrain becomes less hostile, and pressing on to higher elevations stunted beeches make way for alpine grass and then to bare crags. These then were the majestic peaks, towering over myriad jungle clad valleys and ridges, that became the goal of our reconnaissance and beaconing parties.”

## **World War II and its Impact**

In January 1942 the Japanese occupied Rabaul on New Britain and prepared to attack Port Moresby. The Japanese forces landed at Gona-Buna on the PNG mainland on 21<sup>st</sup> July 1942 and by 14<sup>th</sup> August had taken Kokoda and advanced along the Kokoda Track as far as Ioribaiwa by 21<sup>st</sup> September, within 35 miles of Port Moresby, where they were halted by Australian Army forces. In that same month Australian forces defeated a Japanese thrust through Milne Bay at the eastern extremity of the PNG mainland. By December 1942 the Australian forces had recaptured Buna and Gona and by Septemebr 1943 had retaken Lae and Salamua to the west. Throughout these campaigns and beyond until the Japanese surrender in September 1945, several dedicated mapping units of the Royal Australian Survey Corps and hundreds of surveyors and cartographers in the Corps worked tirelessly to support the Australian campaigns across Papua and New Guinea.

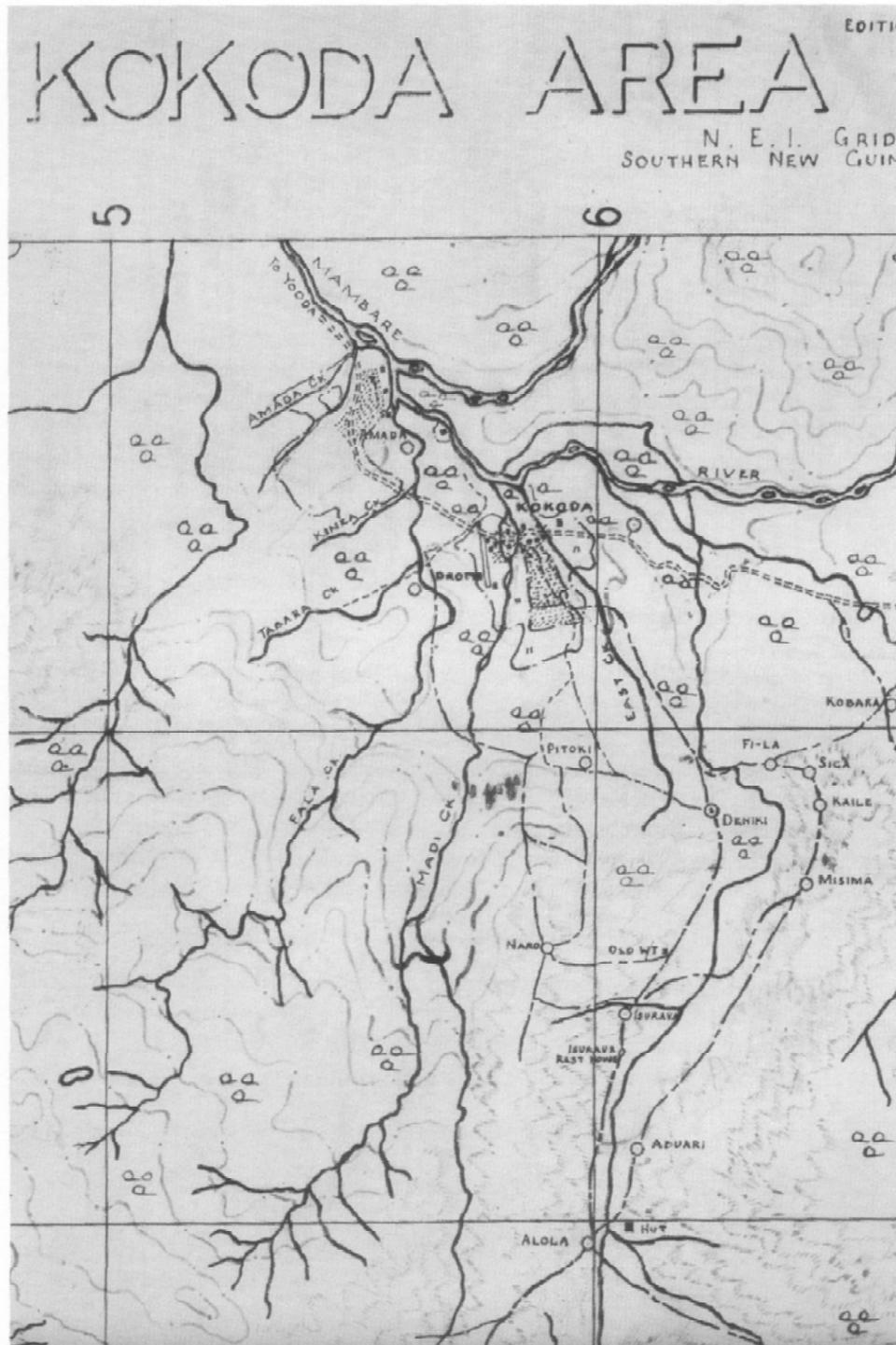
Much is recorded about the roles and tasks undertaken by these military map makers though the three and a half years of warfare in PNG. Sinclair (Sinclair 2001) devotes one chapter of his book *Mastamak* to record some details of wartime mapping and Jack Vickers has written a history (Vickers???) of one of the Units involved (8 Field Survey Section), but the definitive work on the war time efforts of the Survey Corps is the book “Lebanon to Labuan” by Lawrence Fitzgerald (Fitzgerald 1980), the wartime Director of the Survey Corps.

Coulthard-Clark in his history of the Royal Australian Corps (Coulthard-Clark 2000) (pp 88-106) devotes one chapter to the wartime effort in PNG. Some additional details are recorded in the annual Survey Corps Bulletins and some “popular” books on the Pacific war make mention of mapping needs and the general shortage of maps at critical times especially early in the Pacific War.

Sinclair notes that “accurate maps are a prerequisite for successful operations by military forces. Unquestionably the Japanese were severely hampered during their New Guinea campaign by their lack of such maps” (Sinclair 2001) (p. 216) By comparison Paul Ham in his 2004 published book on Kokoda has made many references to the lack of suitable maps for the Australian Forces in the Kokoda campaign. Although Fitzgerald provides considerable evidence about the maps that were available and the mapping effort that supported the fighting forces. Ham states that at the beginning of the Kokoda campaign “there were no accurate maps of the area. People would land in Port Moresby with outdated Shell road maps” (Ham 2004) (p 19). He makes several references through his book to either no maps or inaccurate maps being available to the soldiers in the field. He states that the soldiers of the 39<sup>th</sup> Battalion “were given a little bit of paper naming the villages he would encounter en route, and the approximate marching time between them. Such was the state of allied map making” (Ham 2004) (p. 55). Whilst this is perhaps somewhat removed from the true story, there was certainly a serious lack of suitable mapping to support much of the early fighting of the New Guinea campaign.

Sinclair outlines that leading up to WWII the Survey administrations of Papua and the Mandated Territory of New Guinea had produced some useful topographic maps, mainly of coastal regions but concedes that they were “decidedly sketchy” in many parts. He notes that the Australian Department of the Interior had produced a two sheet map of Papua at a scale of 20 miles to the inch containing only “basic information” and whilst he notes the Australasian Petroleum Company had produced a series of maps at 1:40 000 scale, they did not show relief or vegetation. (Sinclair 2001) (p. 217) These were not very useful for military operations!

The extract below at Figure 1, from Coulthard Clark’s book on the Survey Corps (Coulthard-Clark 2000), shows an extract from the basic map available to the troops at Kokoda in 1942 at a scale of 2 miles to the inch.



Segment of two miles to one inch map of the Kokoda area, produced by 2 Field Survey Section, 1942.

**Figure 1 – Extract from Kokoda map at 2 miles to the inch (1:126 720) in 1942**

In his foreword to Jack Viccars history of 8 Australian Field Survey Section, Brigadier MacDonald somewhat understated the situation: “New Guinea was the most forbidding battlefield of World War II. In particular the area from Port Moresby to Buna where the Kokoda Trail campaign was fought was a military nightmare. The mass of towering tangled mountains and swampy coastal strips had an annual rainfall of up to 100 inches. Dense rainforest covered most of the area and topographical information was so meagre as to be practically non existent.” (Viccars???)

At the commencement of hostilities with Japan in March 1942 a basic Survey Section of the Army was established in Port Moresby, primarily manned with a few technically qualified surveyors and draftsman who were enlisted in PNG. One such surveyor was Lt N. (Jerry) Owers. His early orders were to prepare a location survey for an all weather vehicular track along the southern parts of the Kokoda Track. The ignorance of the terrain by senior officers was entertained for some time in attempting to carry out these orders but eventually they recognised the futility of such an endeavour and advised Owers and his party to “cut a bloody mule track”. The start of this track became henceforth known as the start point of the Kokoda Track at Ower’s Corner.

About half of Fitzgerald’s book on the Survey Corps in WWII(Fitzgerald 1980) is devoted to documenting the work of the Corps in PNG from 1942 through 1945 and it is not appropriate to attempt a full treatment of the topic in this short paper. However some short extracts taken from his work may give some understanding of the scope of the work undertaken in PNG at this critical time of our history.

In his chapter on “New Guinea – The Survey Problem” Fitzgerald, in relating the loss of all mapping records from Rabaul when the Japanese landed, also asserts that “it would not be an understatement to say that nothing of value in the way of surveys and maps existed that could contribute appreciably to the production of the tactical maps required by field forces”. There was “clean slate” when the mapping teams arrived in PNG at the start of hostilities!

From a technical point of view, the nature of the terrain, the lack of any roads, poor air support and constant rain and cloud made traditional survey techniques rather difficult. Triangulation from inter-visible high points was all but impossible due to the terrain. Sun and star observations to fix positions was only possible for very limited periods during stormy afternoons and nights, and the flying conditions and lack of suitable aircraft and cameras made the capture of suitable aerial imagery very difficult.

In the early days of the Kokoda hostilities air support was available to the Corps from a section of the US 8<sup>th</sup> Photographic Reconnaissance Squadron. It had a unique set up of three 6 inch focal length cameras with a 9 inch by 9 inch format, with one vertical and the other set up at 30 degrees oblique view fore and aft. This tri-metrogon set up gave great ground coverage but presented considerable challenges in creating maps from the oblique images without any suitable

ground control. By mid August 1942 2 Fd Svy Sect had acquired tri-metrogon imagery of much of the Kokoda track and proceeded to produce rudimentary maps for use in the field, updated “on the run” by patrol reports as they came in. The only map printing equipment in PNG at the time was dyeline machines using sunlight for exposure during daylight, capable at best of 250 copies per day. Bulk printing was done at the 2/1 Cartographic Coy based near Toowoomba in Queensland with suitable air transport to support delivery of raw mapping data from Moresby to Toowoomba and then rapid production, printing and delivery back to the forces in the field. By the time the Japanese had been driven back to Buna- Gona, good standard 4 inch to one mile scale mapping of the battlefield was available. An example of the turn around achieved in these circumstances was the Buna ¼ inch map manuscript sent from Moresby to Toowoomba on 5 November 1942. It was received there on 6 November and 1000 copies of the printed map were delivered back to Moresby to reach the forward troops in the field by 10 November. In early 1943 2/1 Cartographic Coy deployed a major part of its capability to PNG under the command of Major Bruce Lambert, in post war years to become Director of National Mapping for Australia.

As the Australian Forces advanced against the Japanese through 1943-44, the various Survey Units deployed to PNG continued to provide timely survey and mapping support to all elements of the operations, mostly across the Northern parts of New Guinea and into Borneo leading up to the Japanese surrender at Morotai in September 1945. The Volume of the Official War History on Maps and Survey notes that “the peak of the mapping effort was reached in preparation for final operations in Borneo”, and saw “the production of map series which were better than any produced for previous operations in the theatre”(Clough 1952) (p.528).

After the successful Australian assault on Lae and Finschhafen in 1943 a letter of commendation for the work of the Corps was sent from the Supreme Allied Commander in the South West Pacific, General MacArthur to General Blamey, the Australian Force Commander. MacArthur wrote:

“The performance of 2/1 Australian Army Topographic Company, the 3<sup>rd</sup> Australian Field Survey Company and the 8<sup>th</sup> Australian Field Survey Section of New Guinea Forces, assisted by a detachment of the 69<sup>th</sup> United States Engineer Topographic Company towards the production maps, photomaps and hydrographic charts is worthy of high commendation.

Great technical difficulties were surmounted in producing and distributing maps and photomaps covering more than 12 thousand square miles in time for operations, from combat type photography never before used in this theatre. Astronomic locations vital to the success of the other Allied mapping efforts were obtained under conditions of hardship and grave difficulties of transportation and, upon occasions, considerable risk.

This untiring effort to provide combat units with the maps needed when they were needed, from the material at hand, reflects great credit upon the officers and men of these organisations.” (Fitzgerald 1980)(p. 83)

At the end of the war in August 1945 there were a total of 862 all ranks of the Survey Corps on active duty in the South West Pacific.

Map production of the Survey Corps for the PNG region during the war is summarised in Table 1 below:

Area	4 Miles to the Inch	1 Mile to the inch	1:25 000 and 1:20 000 scale	Total map sheets
New Guinea and adjacent islands	33	118	93	244
Dutch New Guinea	2	6	8	16
New Britain	1	17	12	30
New Ireland	6			6
Bougainville	2	24	42	68

**Table 1 – Map series produced by the Australian Survey Corps: World War II – PNG**

**(taken from(Fitzgerald 1980))**

## **After the War**

In October 1945 Colonel Jack Keith Murray was appointed the new civil administrator of the Territory of Papua and New Guinea, created by an Act of the Australian parliament, thus combining the two previously separate territories of Papua and New Guinea. The devastation of 4 years of warfare across much of the new Territory presented many challenges with most infrastructure and industry destroyed. The records of the old New Guinea Department of Lands Surveys, Mines and Forests were destroyed by the Japanese at Rabaul, but the records of the Papuan Administration were largely transferred to Australia during the war and preserved. The prime task of the newly formed Department of Lands Surveys and Mines was the restoration of land titles. The new service based its survey practices on the old Papuan system, largely derived from Queensland practice. It was not until 1960 that a reorganisation of the Lands Department saw the establishment of a Geodetic Survey Section and map compilation section and it was 1971 before a Central Mapping Bureau was formed within the PNG bureaucracy.

## **Post War Mapping**

In the immediate Post War period the American Military in conjunction with elements of the Royal Australian Survey Corps carried out mapping operations (Projects Cutlass and Xylon) in New Britain and New Ireland with 1:50 000 mapping completed by 1960. By 1962 the US Army Map Service had completed an initial series of 1:250 000 maps for most of PNG.

The 1960's saw a major effort by Australians to complete the survey control framework for PNG and through the 1970's the Royal Australian Survey Corps completed the monumental task of a comprehensive map coverage of the whole country with 1:100 000 maps.

## **Technology Impacts on Mapping in PNG**

Apart from the Australian Government's considerable commitment of both civil and military resources to the mapping of Papua New Guinea through the 1960's and 70's, a number of technological advances made the task of obtaining survey control and mapping an achievable objective within a relatively short time frame.

Through the early 1900's the measurement of survey control networks were largely through a triangulation technique where a baseline was measured very accurately and from there a number of angular measurements were taken at inter-visible points linked to the baseline with all angles in each triangle measured accurately to give redundancy. This was supplemented by sun and star observations (astro fixes) to provide azimuth directions linked to latitude and longitude. In the early 1960's electronic distance measurement became reality with the arrival of the first tellurometers which were able to measure accurately over long distances. This allowed triangulation by measurement of distance rather than just angles. This method still relies on inter-visibility between stations. These instruments came into use by National Mapping and the Royal Australian Survey Corps in the 1960's. A variation of this technique, which is very useful in difficult terrain, was the Aerodist system which involved the use of airborne distance measurement from a mobile airborne platform to fixed ground stations. Another technological development to aid the mapping effort was the Radar Air Profile Recorder (APR) which recorded a height profile over the land as the aircraft flew a grid pattern of sorties to capture height profiles. This was first deployed to PNG in 1963. Tellurometers, Aerodist systems and the Air Profile Recorders were all used extensively in the early efforts to gather map control points in PNG through the 1960's and 70's.

In the early 1970's satellite based positioning also became a feasible technique for capturing ground control points. The predecessors of the current day GPS satellites were a real boost for acquiring accurate survey control in remote areas, such as PNG. The Survey Corps used this technology extensively through the 1970's throughout PNG. In conjunction with new surveying positioning techniques, Rotary Wing aircraft became a real option for movement of men and equipment in the inhospitable terrain of PNG, and helicopter insertion of survey parties became "modus operandi" for survey parties in PNG, from the mid 1960's.

As advances were made with the acquisition of ground control for mapping so too did the science of photogrammetry evolve and the quality of metric air cameras improve considerably,

making the capture and processing of aerial photography for mapping a much more reliable process. The 1970's were also the foundation times for digital mapping techniques where map data was captured from aerial photography as digitised points and lines, considerably speeding up the process of map making.

Whilst the challenges of the terrain and weather in PNG, and the movement of men and materials in this environment were still considerable, these technological advances made an otherwise impossible task achievable. The Royal Australian Survey Corps was at the leading edge of all of these developments and the combination of all these factors contributed in a substantial way to the successful completion of the high quality topographic map coverage of PNG.

By the 1960's the use of aerial photography had become the normal method of capturing data for the production of topographic maps, however in order to relate the data from this photography to the ground and produce accurate maps to scale and on a known map projection, a considerable amount of ground control points, identifiable on the photography were required. Thus the first essential task of a comprehensive mapping program was the establishment of a network of ground survey stations permanently marked on the ground. This backbone of Survey Control was also essential for any coordinated land administration system for land titles or infrastructure development.

## **The Geodetic Survey of PNG**

John Allen & David Cook who worked in PNG on the project have written an unpublished personal account of the work of the Australian Division of National Mapping in the Geodetic Survey of PNG. The information below is largely extracted from that paper. (Cook 2001?)

In July 1958, at the request of the Administrator of PNG, for advice on how best to satisfy their serious mapping needs, the Director of National Mapping, B.P. Lambert flew to Port Moresby. He attended conferences of the Technical Committee on Photogrammetric Mapping and made a wide aerial reconnaissance of the area to form an appreciation of the requirements.

A fundamental conclusion was reached being that a proper geodetic framework was required over PNG as soon as possible, and that the framework should be connected to the Australian network. Following that conclusion, two main traverses were planned – one around the coastline (low) and another along the central ranges using the major peaks (high), with selected connections between these high and low surveys.

This geodetic survey of Papua New Guinea became a joint operation by the Royal Australian Survey Corps and the Division of National Mapping. The Army's responsibility was to establish survey control around the coastal perimeter, and the Division's to establish geodetic control throughout the mountain ranges.

The need for this work is illustrated by one of the most serious errors in the existing control data and maps. Mt Kenevi is just to the east of the Kokoda Gap in the Owen Stanley Range. This peak had been wrongly identified and given a height of 8,487ft, when it was actually 11,315ft. Five wartime wrecks lie around its slopes at heights above that shown on the original maps. One of these wrecks was that of an Avro Anson, LT294, that crashed on 30<sup>th</sup> January 1944. Killed were Group Commander Frederick Wight, the most senior RAAF officer to go missing in WW2, and Wing Commander Keith Rundle. Shortly after the erroneous height of Mt Kenevi had been discovered during Natmap's survey, the remains of the two airmen were recovered and buried at Bomana War Cemetery on 5<sup>th</sup> March 1965.

The National Mapping survey work of the mountain high points was carried out in 2 phases, the first being the selection of suitable reference points on each peak and the placement of ground marks and permanent survey beacons. The second phase was the actual observations to fix the points. The first phase was done without any helicopter support but by 1963 two Bell supercharged helicopters from the Sydney based Helicopter Utilities were available for these operations. One was used by the National Mapping team and the other by the Survey Corps team.

From 1962 to 1964 the National mapping teams beacons a total of 18 points on mountains across the whole of the spine of PNG and some major offshore islands. These ranged in height from around 8000 feet to the 13,240 high Mt Victoria. There was virtually no road network in PNG and for all the beaconing work the only means of access to mountain peaks was to fly to the nearest airstrip and then walk. Once parties were in position the building materials and other supplies were often delivered by airdrops from Cessna fixed wing aircraft.

The observations were completed in January 1965. A rewarding detail for the team was hearing that the network of reciprocal vertical angles from peak to peak, after least squares adjustment by Chief Surveyor Tony Bomford, agreed with mean sea level determinations at Port Moresby across to Lae to within about one foot. In the words of Cook and Allen "It was all a wonderful privilege and even the onset of malaria some months later to a few of our team was of little consequence when we looked at the bigger picture of this remarkable period".

### **The Royal Australian Survey Corps in Post war PNG**

As mentioned previously, soon after WWII, in 1954, the Royal Australian Survey Corps began work with the American Army Map Service on the mapping of New Britain and New Ireland. This began a continuous presence of the Corps in PNG mapping for over 40 years until 1995 when the last Army Survey advisors from the Corps departed PNG. Unfortunately the history of this involvement is not well recorded, although a few publications have made some reference to the work. Val Lovejoy's book on the history of the Army Survey Regiment (Lovejoy 2003) records some details of the Regiment's role in the mapping of PNG and Chris Coulthard-Clarks's history of the Corps (Coulthard-Clark 2000) makes some fleeting references to the post

war effort in PNG. A number of Survey Corps Bulletins (Royal Australian Survey Corps 1980; Royal Australian Survey Corps 1982; Royal Australian Survey Corps 1984; Royal Australian Survey Corps 1985) provide some insight into the effort. The only reasonably comprehensive summary of the Corps effort in PNG is Alex Laing's small booklet of some 16 pages titled "The End of an Era" of which 10 pages record the post war activities. The following is an attempt to summarise a topic which could easily fill a small book.

In the early 1950's some survey parties, deployed from Northern Command Field Survey Section, based in Brisbane, completed field work for the revision of the wartime maps of Manus Island at 1:25 000 scale. In 1954, a specially raised unit, the New Guinea Survey Unit, consisting of 3 officers and 27 other ranks, worked with the Americans on Operation XYLON carrying out "Ship to Shore" Surveys around New Britain. In 1956-7 these operations continued through New Ireland as Operation CUTLASS, but with the newly formed Topographic Squadron from the Army Survey Regiment in Bendigo as the Australian element.

In 1962-3 the Topographic Squadron was again deployed to PNG to carry out the coastal elements of the Geodetic Survey of PNG, and a HIRAN project in conjunction with the US Army to connect the surveys of New Britain, New Ireland and other island networks to the geodetic framework on the mainland. In 1965 the Topographic Squadron again deployed to PNG to carry out Aerodist operations along the North Coast and into the Central Highlands.

By 1969, 1 Field Survey Squadron was established in Brisbane and carried out Operations in PNG, mainly for Aerodist data collection. Through this period a number of Survey Corps personnel were deployed with the Royal Australian Navy on beach surveys around most of the PNG coastline.

According to Done in his 1985 paper (Done 1985) in the period 1974-1979 the Royal Australian Survey Corps fixed the position of some 202 ground control points using the Doppler Satellite techniques. This was done using the AN/PPR -14 Geociever equipment and the US Navsat system, a forerunner to today's GPS satellite constellation. This work was largely carried out by personnel from 8 Field Survey Squadron based in PNG.

In 1972 and 1973, 4 Field Survey Squadron, from Adelaide, was deployed to PNG and was based in the Highlands, again carrying out Aerodist Operations. During these operations the only fatal accident in the whole of the Corps post war activity in PNG occurred when an Army Aviation Corps Sioux helicopter crashed on the slopes of Mt Wilhelm, the highest peak in PNG. The pilot Kevin Shoppe was killed. The Survey Corps soldier onboard at the time, Colin Darch, survived and was rescued the next day.

### **The Clouds Break!**

Probably the most significant breakthrough in the formidable task of mapping PNG was Skai Piksa – the Melanesian Pidgin language term for aerial photography.

According to the Val Lovejoy's account (Lovejoy 2003)(p. 88) the concept for capture of the badly needed photography of PNG originated with two Sergeants at the Army Survey Regiment, Jim Mitchell and Brian Rogers. They developed a proposal to fit the new RC10 wide angle cameras into the RAAF's Canberra bombers. As 2 Squadron RAAF had recently finished their work in Vietnam, and the aircraft were not required elsewhere, the project (Skia Piksa) was approved in 1973 and the aircraft deployed to PNG in 1973, 1974 and 1975. The wide angle lenses of the RC 10's coupled with the ability of the Canberra bombers to fly at up to 40 000 feet were ideally suited for the capture of high resolution photography at a scale of around 1:60 000 - 1:80 000, which gave fewer images to be corrected and was well suited to compilation of 1:100 000 scale mapping. In addition, the capability of the Canberra bombers to deploy quickly and their endurance in the air meant that they could move across the airspace of PNG above the terrain and work where the cloud cover was least at any particular time. The results of this endeavour were spectacular with most of the country photographed cloud free in the first year of operations and virtual 100% cloud free coverage achieved by the end of the 1975 flying season. The basic raw materials for the ambitious 1:100 000 mapping program - a geodetic standard set of ground control points, and quality cloud free imagery - were now in place.

### **The Mapping Process as used for PNG Topographic Mapping**

In order to understand the scope of field operations applied to mapping carried out in PNG through the 1960's and 70's, an outline of the complete mapping process as applied by the Royal Australian Survey Corps at the time will provide some insight as to how the field work and office based procedures came together to produce a printed (or digital) map.

The whole mapping program in PNG in this period was based on the extraction of the majority of map content from metric quality aerial photography. The accurate absolute and relative position of this data in relation to the actual terrain and into a universally accepted map projection and grid are also essential ingredients.

In this instance the Geodetic Survey of PNG in the mid 1960's and the acquisition of the Skia Piksa imagery in the mid 1970's provided two of the essential building blocks for the program.

In very basic outline the following activities describe the map making processes employed at the time from data acquisition through to printed map:

- **Ground Control**

Sufficient survey points on the ground were required to allow the orientation and scaling of the aerial photography in stereo-plotting instruments (mainly Wild B8's) to allow compilation of preliminary map manuscripts. Within a run of photography sufficient points identifiable on the imagery were required for azimuth and scale to be transferred to the map manuscripts. The photogrammetry adjustment process is quite technical and scientific, based on much high level mathematics and trigonometry coupled to

sophisticated computer programming and will not be further described here, however there are a minimum number of ground control points required for each photography run and to connect between runs. In the case of the 1:100 000 mapping of PNG the fact that the aerial photography coverage was acquired as a consistent standard coverage from one camera type meant that the Photogrammetrists in Topographic Squadron at the Survey Regiment could specify to surveyors in the field the location and number of points required in a particular mapping area. Thus marked up imagery was supplied to the field surveyors identifying the desired location of the ground control points for them to plan the operations to acquire this control. In PNG there are many offshore islands and for each of these at least one point and an azimuth fix are also needed.

Operational areas were thus defined within the country and field trips of 3-6 months durations planned over several years to acquire this ground control. The control points acquired were linked into the geodetic framework. For PNG a mixture of technology approaches were used with tellurometer traverses, aerodist measurement and APR profiles being used mostly on the mainland. The majority of control through the 1970's was acquired using the satellite based positioning from the AN/PPR -14 Geociever equipment throughout the island groups, especially to the North and East of the mainland. For each point established a permanent mark was placed in the ground, with suitable nearby reference points marked and recorded. Generally plastic panelling was laid at the point and spot photography flown soon after to allow identification of the points for transfer to the mapping photography.

- **Stereo plotting**

With the ground control now established and transferred to the mapping photography, blocks of imagery were adjusted and prepared for stereo-plotting by the photogrammetrists at the Regiment. The preliminary map manuscripts were plotted in four separations – Culture (man made features such as roads and villages), Drainage, Vegetation and Relief. Most of this work was done at the Regiment in Bendigo, but some was sent to the Four Field Survey Squadrons in Australia. The outcome of this process was a preliminary map to scale and on projection. A short run of these maps in colour were printed and sent back to the PNG for field verification.

These preliminary maps captured all of the information identifiable from the aerial photography. In general the relief was in the form of spot heights and contours and required no checking. The drainage again was usually accurate but did require some verification, especially in mountainous areas. The vegetation was generally accurate but often land clearing had occurred between when the imagery was acquired and the field completion time. The main effort of field completion was concentrated on the cultural features of the map. Names required particular attention with the necessity to check all

local sources for correct names of all features, but all roads, tracks (including walking tracks), villages, townships, bridges and airfields all required checking.

- **Field completion**

The main method of field checking in PNG was from Rotary Winged aircraft with a range of helicopters being used for the task, including Army, RAAF and civil hire aircraft. Generally a small party of survey technicians were deployed to an area where several map sheets had been completed. Support was generally just one helicopter, but in the case of the RAAF usually two Iroquois were online at any one time. The process involved systematically flying over a map sheet area and recording by hand any changes to the manuscript. In areas where large changes were identified some hand held photography supplemented the manual notations and in cases of substantial change, supplementary aerial photography was acquired. The field work also entailed visiting any local government officials, missionaries or companies operating in the area who could provide useful information on nomenclature. At the conclusion of each sortie clean copies of manuscripts were prepared and when the parties returned to their home base (mostly 8 Fd Svy Sqn) these sheets were checked and quality audited before despatch back to the Regiment.

- **Cartographic Compilation, Lithography and Printing.**

The field correction sheets were used by Cartographic Squadron at the Regiment to produce final map quality compilations and the subsequent scribed transparencies for each colour separation of the final maps. The final transparencies were then used to make the printing plates for map printing carried out by Lithographic Squadron who printed the multiple copies of the final map. Copies of the final map made their way back to the field teams so they saw the final fruits of their labours!

## **8 Field Survey Squadron**

The most significant deployment of the Survey Corps in PNG began in 1971 when a specific unit, 8 Field Survey Squadron, was raised and permanently deployed to PNG. This unit spent 3 years based at Popondetta, followed by another 5 years at Wewak, working on all aspects of the PNG mapping program. The strength of the unit through this period was generally around 3 Officers and 25 other ranks. A reduced sized contingent of the Squadron continued to be based in Port Moresby from 1980 until eventually disbanded in 1995. Over the period to 1985 a total of some 150 all ranks served in the Unit. Annex A to this paper is a list of those soldiers who served in the unit.

The Squadron was initially deployed to Popondetta and Major Alex Laing was the inaugural Officer Commanding. He was later to be Director of the Corps for several years. The unit occupied facilities previous used by the District Engineers Office, which was manned by soldiers

of Royal Australian Army Engineers, who had moved to Mendi in the Highlands. A number of houses in the town were occupied by the families of married members and single soldiers had their own quarters for when they were at home, which was not very often. Being located in an area that was so pivotal to the early Army operations in WWII against the Japanese gave a interesting cultural aspect to the Squadron's work, with Buna, Gona and Kokoda all accessible by road and many WWII airfield and artefacts still strongly visible.

When the unit transferred to Wewak in 1974 it was co-located with the 2<sup>nd</sup> Battalion of the Papuan Infantry Regiment (2PIR) at Moem Barracks. Many of the officers in 2PIR at the time were Australian and the Commanding Officer was Mike Jefferies, later to be Australia's Governor General. Wewak was also the home region of Michael Somare, the first Prime Minister of PNG. The squadron was based at Wewak through PNG Independence in 1975 and often saw Michael Somare around the barracks – usually on the Golf Course. The barracks had good quality accommodation and facilities included a 9 hole golf course, sports grounds, an Olympic sized swimming pool, gymnasium and squash courts. Wewak was also a substantial township with good facilities, including a couple of hotels. It was a pleasant place to come back home to after long periods in the field. Wewak also had a strong military history from WWII operations with the surrender of the Japanese in PNG taking place there.

The author was posted as the Operations Officer of 8 Fd Svy Sqn in early 1975, as a newly graduated Surveyor from RMIT, and spent the next two years working throughout PNG on various mapping operations. The following is based on his experience in these two years and subsequent posting to the Army Survey Regiment as 2IC of Topographic Squadron who were still working on PNG mapping at that time.

As previously described the two major field tasks in the mapping program were the acquisition of ground control and the field completion of preliminary maps, and 8 Fd Svy Sqn was very active on both fronts. The Squadron was equipped with some B8 Stereoplotters but these were only used occasionally for miscellaneous mapping work,(such as project maps for the PNGDF) as the plotting of the 1:100 000 series maps was completed by Australian based units of the Corps. The unit was also involved in managing the capture of spot photography and some supplementary mapping photography, mostly using Army Pilatus Porter aircraft.

Some details from the mapping control operations in the Louisiade Archipelgo, provide an insight into the operational challenges and achievements of this period. The Louisiade Archipelago is the island chain stretching east and north east from the eastern extremity of the PNG mainland at Milne Bay. To the North are the Goodenough, Fergusson, Trobriand and Woodlark Islands and the chain to the East stretches from Samurai to Misima and Tagula Islands out to Polkington Reef, the eastern extremity of the Country.

Operations Sandy Bush and Lahara were conducted in 1975 and 1976 respectively and acquired all the necessary ground control required for mapping of the island chains to the north and east of

Samarai in Milne Bay province. The tasks carried out included the establishment of permanent survey marks, including the clearing of stations, suitable marking and referencing. Each station was occupied by parties of two soldiers for a period of 2-4 days each with geociever equipment used to record a minimum of 14 satellite overpasses to fix the points to 3rd level accuracy. Some additional survey work by tellurometer and astro fixes was also completed. The points were panelled with black or white plastic panels (black was used on sandy white beaches) and identification photography flown over each point using Wild RC 10 cameras mounted in a civil hire Queenair aircraft. Parties were generally inserted and relocated by Bell 206 civil hire helicopters. The operational support to position and move the whole operational detachment included PNGDF Landing Craft (LCH), RAAF Caribou and PNGDF Dakota aircraft. Air support was also supplied from Australian Army Pilatus Porter aircraft for some redeployment and spot photography work. 8 Fd Svy Sqn personnel were supplemented by other soldiers on detachment from Australian based Survey units. Local labour was hired to assist with portorage and ground clearing tasks. The main base moved as required between Samurais, Goodenough Island, Lousia in the Trobriand Islands and Misima Island. The major operation (Operation Sandy Bush) were in 1975 but, as not all tasks were completed that year, another operation (Lahara) was mounted in 1976 to complete the ground control acquisition. This work had additional support from PNGDF Patrol Boats and some civil hire local shipping to move the ground parties to required observation points.

These operations to capture ground control were carried out in the early stage of the map production for these areas, however the Squadron was also busy carrying out field completion of map sheets that had progressed past the initial plotting stage and were now produced as preliminary map sheets, generally in blocks of mapping covering quite large geographic areas. In 1975-6 these field completion operations were based in the Highlands out of Goroka and Mt Hagen and also covered large portions of the Papuan Gulf country, the Fly River delta and PNG islands at the northern extremity of Torres Strait and stretching across to the Indonesian border. This work was carried out using RAAF Iroquois helicopters and some civil hire Bell 206 helicopters. There was a marked contrast between using the RAAF and the civil helicopters. To ensure one Iroquois "online" it was an RAAF requirement to have two aircraft deployed with a full support group of about 14 men. Thus a small troop of 5 Survey soldiers had a "tail" of some 14 RAAF in support. By contrast one civil hire Jetranger had one pilot and one engineer in support.

### **Completion of the 1:100 000 mapping program**

On 10<sup>th</sup> April 1980 the Army Survey Regiment published the 1:100 000 sheet of Lorengau culminating 30 years of effort, starting with the first stages of the Geodetic network in the 1960's through to the last map sheet in the series being completed in 1980. On 26<sup>th</sup> June 1980 the

Australian High Commissioner for PNG presented a complete 3 volume Atlas of the maps in the 1:100 000 series to the Prime Minister of PNG, Sir Julius Chan.

The preface to this atlas states, in part:

“The Royal Australian Survey Corps during and since World War II has been engaged almost continuously upon a programme of Survey and Mapping in PNG. The work has been undertaken with the assistance and co-operation of all Arms and Services of the Australian Defence Force, Papua New Guinea Defence Force, members of the National Mapping Bureau PNG, Division of National Mapping Australia, Royal Engineers Survey (UK), Royal Air Force (UK), Army Map Service United States Army, United States Navy, United States Air Force and numerous expatriate civilians in PNG and PNG Nationals who assisted survey parties in the field on a variety of supporting tasks in the jungles, swamps and mountain peaks of their Country.  
..... At a time when PNG is assuming a position of increasing prominence in the world and regional affairs, I hope this atlas of topographic maps will promote further understanding of the challenge of its environment and will contribute to the successful utilisation of its resources for the benefit of all its peoples and their neighbours”

## **Hydrography**

The work of the Royal Australian Navy in charting the waters of PNG over the last 50+ years has been extensive. Sinclair(Sinclair 2001)( p 287,288) notes the work of a number of Navy Hydrographers through the 1950's and 60's, including HMAS Paluma, Moresby and Flinders under various Captains. Done in his 1985 paper(Done 1985) notes that there is a 1:300 000 scale series of charts for the whole country produced by the RAN although “ there are large gaps and many areas have never been surveyed”. Done also notes that the Snowy Mountains Engineering Corporation (SMEC) has completed a 1:50 00 series of maps/charts for the Fly River on behalf of the Ok Tedi mining conglomerate, through the late 1970's/ 80's(Done 1985). Much of the work of the RAN Hydrographer continues today with the RAN continuing an active program charting the waters of PNG, and training PNG nationals in this field.

## **Lae Unitech**

In considering Australia's role in the mapping of PNG in the post war period, the role of training and education should be recognised. The Survey Corps and the Royal Australian Navy has taken a lead role in training PNG nationals, both military and civilian through the past 30 years, however the University of Technology in Lae in PNG has taken the lead role in the training of PNG nationals in surveying and cartography. Since its establishment in the 1970's, Lae Unitech has provided University level training in the cartographic sciences and contributed significantly to the capability of PNG in this area. Most of the early lecturers at Lae were Australian Nationals with Ken Lyons being Head of Department for a number of years. Ken was an ex Survey Corps

Officer from the Vietnam era and after his time at Lae went on to be Head of Geographic Sciences at University of Queensland for a number of years.

### **Post independence mapping**

After completion of the 1:100 000 mapping programme in 1980 there remained two more years before the complete coverage of PNG with mapping at 1:250 000 scale was completed. This series 1510 mapping was in two versions the Joint Operation Graphic Ground and Air JOG-A and JOG- G, and were largely derived from the 1:100 000 series, using the resources of the Army Survey Regiment with field completion by the 8 Field Survey squadron personnel based in Port Moresby. These were completed in April 1982. A two volume Atlas set of these maps were presented by the Australian High Commissioner to PNG, Mr Birch, to the PNG Minister for Lands, Mr Korowaro, on 26<sup>th</sup> August 1982 in Port Moresby.

A further involvement of the Corps was in assisting the PNG National Mapping Bureau to complete 1:50 000 scale mapping along the PNG /Indonesian border under the project title of Operation Kumul. To this end 2 Field Survey Squadron from Sydney undertook field survey work long the border from 1989 to 1994, and aerial photography of the border region was acquired using civil hire Learjets and Survey Technicians from 4 Field Survey Squadron in Adelaide, and the Regiment at Bendigo. The Regiment produced the final maps along the border.

### **Conclusion**

Australian surveyors, cartographers and hydrographers have a long and proud history working in PNG. The survey control network in PNG is amongst the best in the third world, largely due to the efforts of Australian Surveyors. The country has complete topographic mapping coverage at 1:100 000 and 1:250 000 scale and coverage along the PNG/Indonesian border at 1:50 000 scale due to the efforts of the Royal Australian Survey Corps over a 40 plus year period. This paper has provided a very brief insight into the tireless efforts of many dedicated people in what is a very challenging mapping environment. The work is deserving of much more research, documentation and recognition for what has been a monumental and often heroic task. The base mapping information delivered by Australians for PNG still provides a very accurate knowledge base of the terrain of the nation and underscores the potential for further development of our nearest neighbour and true “wantoks”.

***Annex A:*** 8 Field Survey Squadron Unit Personnel 1971 to 1985

## 8 Field Survey Squadron Unit Personnel 1971 to 1985

Source (Royal Australian Survey Corps 1985)

**UNIT HISTORY.****POPONDETTA**

First parade at full strength 19th day of January 1972

Maj A.W. Laing	Cpl B. Dernoga	Cpl R.J. McHenry
Lt. J.W. Winzar	Cpl. K.J. O'Halloran	Spr. E.Van Ginneken
SSgt. A. Cairney	Cpl. G.D. Knight	Spr. D.J. Rooke
SSgt. P.D. Cox	Spr. J. Knips	Spr. T.J. Wicker
Sgt. J.K. Scharber	Spr. T.H. Allanson	Spr. K.V. Wilkinson
Sgt. A.L. Di Pede	Spr. M. Davey	Pte. M.E. Anderson

**POPONDETTA Jan 72 – Jun 75**

Personnel posted to the unit

Jun 72 Spr. S. Savos  
 Aug 72 Cpl. P. Tangay  
 Jan 73 Spr. D. Williams  
 Jan 73 Spr. K. Talbot-Smith  
 Jan 73 Wo1. S. Chambers  
 Jan 73 Wo2. C. Moule  
 Jan 73 Capt. E.T. Royle  
 Jan 73 Sgt. B.W. Firms  
 Jan 73 Cpl. P.J. Moore  
 Feb 73 Lt. S.W. Lemon  
 Feb 73 Cpl. J. Holden  
 Feb 73 Spr. R. Downie  
 Feb 73 Spr. P. Brunt  
 Feb 73 Spr. G. Hunter  
 Feb 73 Sgt. M. Tamme  
 Mar 73 Pte. D. Kaddatz  
 Apr 73 Spr. A. Thompson  
 Apr 73 Spr. V.I. Fry  
 Apr 73 Sgt. J. Stasiuk  
 May 73 Spr. W. Chilcott  
 May 73 Sgt. J.D. Barrie  
 May 73 Cpl. R. Norwood  
 Jun 73 Cpl. P. Warwick  
 Jun 73 Spr. R. Vanderbom  
 Sep 73 Cpl. B. Garritty

Dec 73 Sgt. M.A. Barton  
 Dec 73 Maj. B.E. Dalton  
 Dec 73 Cpl. P.N. Beaty  
 Jan 74 Sgt. J. Mobbs  
 Jan 74 Spr. R. Tanner  
 Jan 74 Cpl. P.W. Bray  
 Feb 74 Cpl. P.A. Jensen  
 Mar 74 Spr. J.F. Cowie  
 Apr 74 Spr. M. Evans  
 Jun 74 Cpl. P. Speering  
 Jun 74 Spr. B. Van Leeuwen  
 Jun 74 Cpl. P.D. Boyle  
 Jun 74 Cpl. R. Butler  
 Sep 74 Cpl. J.D. Byrnes  
 Oct 74 Cpl. A.B. Creedy  
 Dec 74 Capt. H.E. Hansen  
 Dec 74 Wo2. M.G. Maher  
 Apr 75 Lt. D.J. Puniard  
 Apr 75 Cpl. P.W. Rodriguez  
 Apr 75 Maj. K.J. Murphy  
 Jul 75 Cpl. B.A. Britton  
 Jul 75 Cpl. D. Stanmore  
 Jul 75 Cpl. C.K. Yandell  
 Jul 75 Cpl. R.J. Larsen  
 Jul 75 Cpl. R. Leonard

Jul 75 Cpl. T.D. Pearson  
 Jul 75 Pte. G. Jordan  
 Sep 75 Sgt. W.B. Kemp  
 Oct 75 Cpl. R. Downie  
 Oct 75 Spr. G. Williams  
 Nov 75 Spr. D.T. Carr  
 Dec 75 Sgt. D. Anderson  
 Dec 75 Cpl. B. Lutwyche  
 Dec 75 Wo1. D. Taylor  
 Jan 76 Cpl. A.H. Strain  
 Mar 76 Spr. P.J. Elvard  
 May 76 Cpl. R.G. Cocksedge  
 Jun 76 Spr. J. Gilbert  
 Jul 76 Spr. J. Phillips  
 Oct 76 Cpl. A. Wardle  
 Oct 76 Spr. S. Hilton  
 Dec 76 Wo2. C. Moule  
 Dec 76 Capt. P. Strunks  
 Dec 76 Maj. P.H. Wood  
 Mar 77 Spr. G. Sulman  
 Mar 77 Sgt. G. Dowd  
 Mar 77 Lt. J. Harrison  
 Mar 77 Spr. G. Santo  
 Jun 77 Cpl. J. Jones  
 Jun 77 Cpl. G. Timmins

**WEWAK Jun 75 – Jun 80**

Jul 77 Cpl. P. Meagher  
 Aug 77 Cpl. L. Barrell  
 Aug 77 Cpl. D. Volz  
 Aug 77 Spr. R. Brewer  
 Sep 77 Cpl. P. O'connell  
 Sep 77 Pte. J.P. Byrne  
 Oct 77 Spr. G.P. Wastell  
 Nov 77 Wo2. G. Birrell  
 Dec 77 Cpl. A. Creedy  
 Nov 77 Sgt. G. Fello  
 Jan 78 Wo2. G.E. Burgess  
 Feb 78 Sgt. D.P. Musgrave  
 Feb 78 Cpl. B.R. Whittenbury  
 Apr 78 Spr. P.A. Cheater  
 Apr 78 Spr. P.F. Leskovec  
 Apr 78 Cpl. M.L. Duniam  
 Jul 78 Cpl. P.H. Wandoch  
 Jul 78 Cpl. N.W. Jones  
 Aug 78 Cpl. D.J. Williams  
 Aug 78 Cpl. A.G. Kavanagh  
 Aug 78 Spr. D.S. Valentine  
 Oct 78 Spr. R.M. Green  
 Dec 78 Cpl. J.B. Howie  
 Feb 79 Lt. R.J. McHenry  
 Feb 79 Lt. P.E. Osterhage

**PORT MORESBY**

Personnel posted to the unit

Apr 80 Wo2 G.J. Squire  
 Jul 80 Capt. P.M. Bion  
 Jul 80 Wo2. C.L. Dahlberg  
 Aug 80 Sgt. G.T. Neilson  
 Oct 80 SSgt. P.N. Beaty  
 Oct 80 Capt. R.L. Roche

Jun 81 SSgt. R.J. Williams  
 Jun 81 Wo2. C.E. Darch  
 Aug 81 Sgt. M.P. Coombes  
 Apr 82 Wo1. G.W. Lowery  
 Dec 82 Maj. R.W. Cooper  
 Mar 83 Sgt. S.M. Egan

Sep 83 Wo2. J.D. Barrie  
 Oct 83 SSgt. A.W. Gianville  
 Dec 83 Sgt. R.P. Bogumil  
 May 84 Wo1. J.C. Bennett  
 Dec 84. Máj. S.J. Vote  
 May 85 Sgt. I.R. Nichols

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