Pirates of the Cadastre

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20–22 March 2023

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Editorial

These proceedings contain the papers presented at the Association of Public Authority Surveyors Conference (APAS2023), held in Coffs Harbour, NSW, Australia, on 20-22 March 2023. Papers were not peer-reviewed but have been subject to changes made by the Editor. The Editor would like to thank all authors for their contributions covering a wide range of topics relevant to the surveying and spatial information community, thus ensuring an exciting and informative conference.

Authors are welcome to make their paper, as it appears in these conference proceedings, available online on their personal and/or their institution's website, provided it is clearly stated that the paper was originally published in these proceedings. Papers should be referenced according to the following template:

Janssen V. (2023) Amusing research in surveying and spatial science, *Proceedings of Association of Public Authority Surveyors Conference (APAS2023)*, Coffs Harbour, Australia, 20-22 March, 3-25.

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Amusing Research in Surveying and Spatial Science

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ABSTRACT

Amusing research can improve student learning of a topic and make it more accessible to a more general and more diverse audience, thereby contributing to a better understanding of science in the general public. Humorous science generally applies serious science to unusual but intriguing research questions, while also including the occasional spoof paper. Often, it includes a more serious message hidden between the lines or disguised by tackling a ridiculous topic. This paper highlights some of the weird and wonderful research findings hidden amongst the scientific literature related to surveying and the spatial sciences, aiming to ensure that we remember the funnier side of science and providing answers to questions that we may have been too afraid to ask. Topics covered include producing and presenting research, mysteries encountered in the workplace office, employing vampires and zombies to solve scientific problems, innovative approaches to animal mapping and ecology, grappling with applied physics in our professional and everyday lives, Work Health and Safety (WHS) considerations and examples from surveying practice.

KEYWORDS: *Science humour, learning, data collection, modelling, data analysis.*

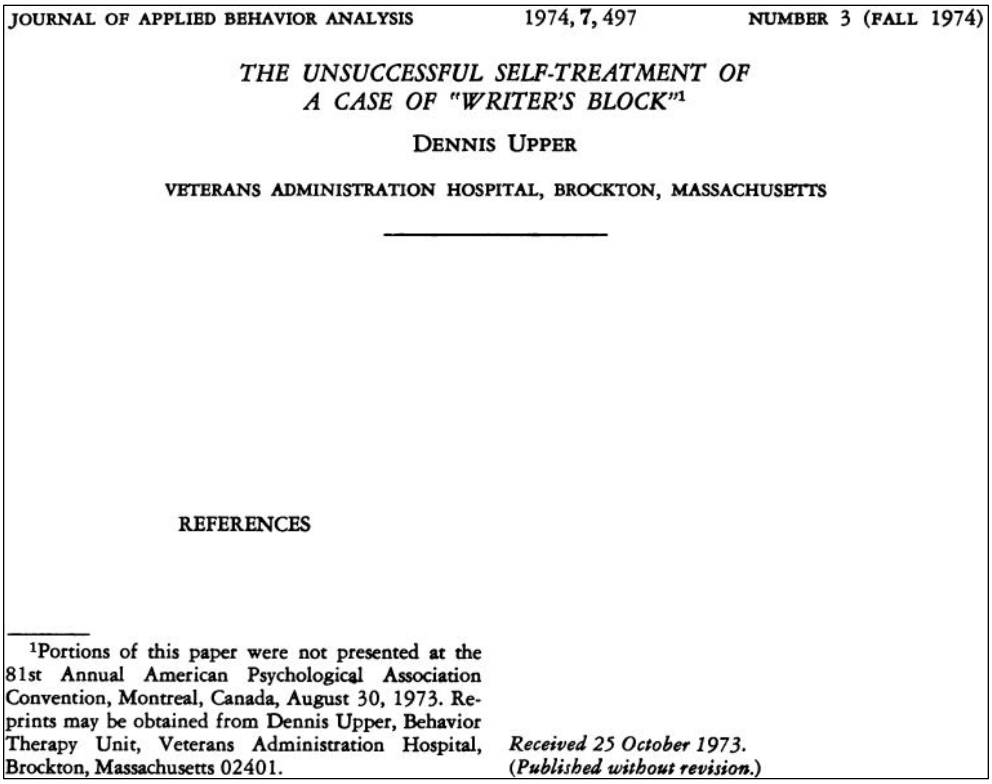
1 INTRODUCTION

The fascinating world of amusing research generally applies serious science to unusual but intriguing research questions, while also including the occasional spoof paper. Humorous science can improve student learning of a topic (e.g. McAlister and Hills, 2023) and make it more accessible to an outside (more general and more diverse) audience, thereby contributing to a better understanding of science in the general public. Often, there is also a more serious message that is hidden between the lines or disguised by tackling a ridiculous topic.

This paper highlights some of the weird and wonderful research findings hidden amongst the scientific literature related to surveying and the spatial sciences, based on the author's series of papers on humorous science (Janssen, 2021a-e, 2022). It aims to ensure that we remember the funnier side of science and provides answers to questions we may have been too afraid to ask. Topics include producing and presenting research, mysteries encountered in the workplace office, the contribution of vampires and zombies to solving scientific problems, innovative approaches to animal mapping and ecology, dealing with applied physics in our professional and everyday lives, Work Health and Safety (WHS) considerations, as well as some examples from surveying practice. This study was conducted entirely in the author's spare time and is in no way related to his employer.

2 WRITING AND PRESENTING A PAPER

Starting with the difficulty to write an academic paper, Upper (1974) famously reported on the unsuccessful self-treatment of a case of writer's block (Figure 1). The reviewer mentioned at the time: "I have studied this manuscript very carefully with lemon juice and X-rays and have not detected a single flaw in either design or writing style. I suggest it be published without revision. Clearly it is the most concise manuscript I have ever seen – yet it contains sufficient detail to allow other investigators to replicate Dr Upper's failure." More than three decades later, this indeed spawned a multi-site cross-cultural replication of the study, showing a remarkable agreement of results between the two (Didden et al., 2007).


JOURNAL OF APPLIED BEHAVIOR ANALYSIS 1974, 7, 497 NUMBER 3 (FALL 1974)

THE UNSUCCESSFUL SELF-TREATMENT OF A CASE OF "WRITER'S BLOCK"[1]

DENNIS UPPER

VETERANS ADMINISTRATION HOSPITAL, BROCKTON, MASSACHUSETTS

REFERENCES

[1]Portions of this paper were not presented at the 81st Annual American Psychological Association Convention, Montreal, Canada, August 30, 1973. Reprints may be obtained from Dennis Upper, Behavior Therapy Unit, Veterans Administration Hospital, Brockton, Massachusetts 02401.

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Figure 1: Unsuccessful self-treatment of writer's block (Upper, 1974).

By applying scientific rigour to an entertaining topic, Janssen (2019) demonstrated how one can collect, analyse, interpret and present data by effectively utilising tables, pie charts, time series, histograms and maps. He focused on the rock band AC/DC, examining song lyrics, the band's work rate, the passion of hardcore fans and the marketing of the AC/DC brand. It was found that the word 'rock' is by far the most prominent in AC/DC song titles but lyrically almost half of all songs revolve around sexual encounters. While the frequency of album releases slowed considerably over time, the band generally played 150 live gigs following each studio album in increasingly larger venues. Bon Scott (†1980) songs continue to make up 45% of typical AC/DC concert setlists, demonstrating the immense respect for his contribution, the quality of the early song material and the timelessness of AC/DC's music. Analysis of a questionnaire revealed that hardcore fans generally preferred the older material, experienced their first gig during early adulthood and enjoyed up to 124 gigs since.

Research findings are often presented at conferences and seminars. Rockwood et al. (2004) explored how often attendees nod off during such scientific meetings and examined risk factors for this behaviour. After counting the number of heads falling forward during a 2-day lecture series attended by 120 people (this method was chosen because counting is scientific), they calculated incidence density curves for nodding-off events per lecture (NOELs) and assessed risk factors using logistic regression analysis. The quality of the lectures varied from entertaining and informative to monotonous and repetitive, to rushed and surreal. The incidence density curve ranged from 3 to 24 NOELs, with a median of 16 NOELs per 100 attendees (Figure 2).

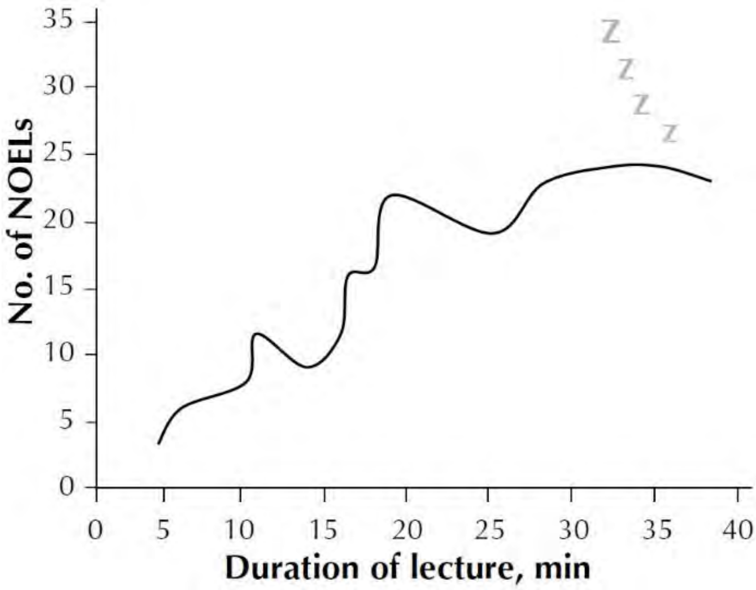

Figure 2: Special incidence density curve, showing the number of nodding-off events per lecture (NOELs) per 100 attendees as a function of presentation time (Rockwood et al., 2004).

Identified risk factors for nodding off included environmental factors (dim lighting, warm room temperature, comfortable seating), audio-visual factors (poor slides, not speaking into the microphone) and circadian factors (early morning, post meal), but speaker-related behaviour (monotonous tone, tweed jacket, getting lost in the presentation) provided the strongest risk. A questionnaire administered to those who nodded off revealed that most were comforted to know they were not alone and that it was predominantly the speaker's fault. Most had no enthusiasm to attend boring presentations but were influenced by continuing professional development (CPD) credits, guilt or obsessiveness.

Since this paper generated considerably more interest than the authors' more conventional publications, they decided to write a follow-up (Rockwood et al., 2005). Here, they performed a comprehensive, international systematic review of nodding off and napping during medical presentations, spanning more than 100 years (but only three papers during that time, including their own). The results suggested that tranquillising lectures are common, annoying and persistent, with low lighting and boring (and badly presented) contents being the main risk factors for nodding off. The authors also provided a few tips on how to help increase the attention a paper may receive after publication through ingested keywords, citations and tweaking the methodology to exclude unwanted references.

Considering the student perspective, Adams (1999) studied the worrying dead-grandmother exam syndrome. This implies that a student's grandmother is far more likely to die suddenly just before the student takes an exam than at any other time of year (particularly if the student's current grade is poor). Based on 20 years of data, he determined that a student who is about to fail a class and has a final exam coming up is 50 times more likely to lose a family member than an excellent student not facing any exams. This clearly showed that family members literally worry themselves to death over the outcome of their relative's exam performance.

3 WORKPLACE OFFICE MYSTERIES

The nocturnal activity patterns of an endangered population of the common fork were investigated by Henckel (2005) from the School of Cutlery at the Institute of Inanimate Objects and Existential Phenomenology in Sydney (good luck tracking this author down). This fork-stabbing study was most likely inspired by the dynamic behaviour of cutlery in a typical office environment. Through an extensive survey program, he examined nocturnal fork activity and provided management recommendations to assist with the conservation and long-term viability of the population.

Spotlighting was used as the basis for a targeted trapping program of individual forks. Captured forks were barcoded and fitted with a radio-collar that also included a movement sensor and mortality switch. Mean nocturnal activity data was used to calculate and spatially visualise minimum convex polygons, followed by a modified temporal Jacobian cross-legged twirl non-parametric analysis to create four activity classes (i.e. regular, high, extra high and super). A non-linear Mulder and Scully prime time analysis was then conducted to determine common fork microhabitat preferences. The results indicated that the fork population utilised approximately 0.1 ha of habitat, including an area of extreme activity representing core habitat around the communal tearoom (Figure 3).

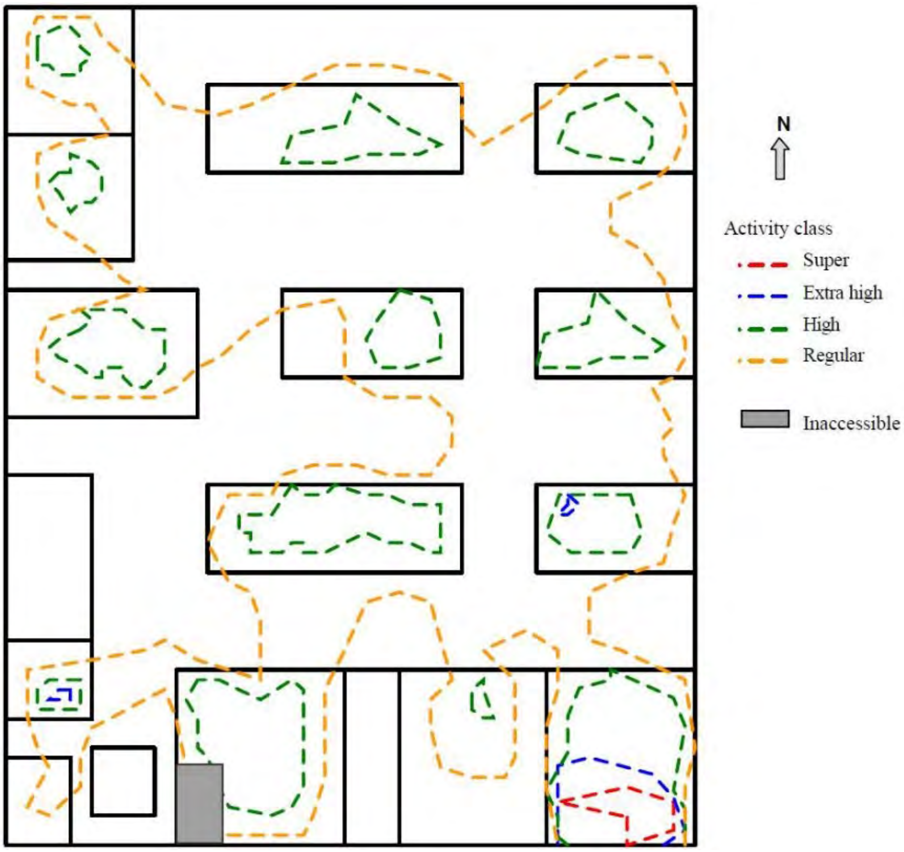

Figure 3: Nocturnal activity levels of the common fork in an office environment, noting the tearoom in the south-eastern corner (Henckel, 2005).

Monitoring of individual forks revealed that the mean travel distance plateaued at 5 days, after which no extension of travel distance was observed. It was noted that some of the identified habitat may have displayed a higher-than-expected fork activity level due to individual humans not returning forks to the tearoom when finished. This could have resulted in a type II error, identifying certain areas to be of greater use to forks than they actually are.

Lim et al. (2005) determined the overall rate of loss of workplace teaspoons in an Australian research institute and investigated whether attrition and displacement were correlated with the relative value of the teaspoons or type of tearoom. After distributing 70 individually numbered teaspoons throughout eight tearooms, weekly counts were carried out for 2 months, then fortnightly for another 3 months. Desktops and other immediately visible surfaces were also scanned for errant spoons. After 5 months, this previously covert research project was revealed to the institute's staff, who were asked to return or anonymously report any marked teaspoons that had made their way into desk drawers or homes. Staff were also asked to complete an anonymous questionnaire about their attitude towards and knowledge of teaspoons and teaspoon theft.

It was found that 80% of the teaspoons disappeared during the study period. The loss was rapid and not influenced by their value, showing that teaspoon availability (and hence office culture in general) is constantly threatened. The teaspoon half-life was determined to be 81 days, i.e. half had permanently disappeared after this time. However, the amount of time a teaspoon survived in its final room varied significantly according to tearoom type: half-life of 42 days for communal tearooms and 77 days for rooms associated with particular research groups (Figure 4). Applying the annual rate of teaspoon loss per employee to the entire workforce of the city, they estimated that 18 million teaspoons go missing in Melbourne each year. Laid end to end, these would extend over 2,700 km (the length of the entire coastline of Mozambique) and weigh over 360 metric tons (the approximate weight of four adult blue whales). It was speculated that the missing teaspoons may be escaping through space to a world inhabited entirely by spoon life-forms, although workplace kleptomania and laziness may provide a more likely answer. Consequently, substituting your next birthday cake for a new bunch of forks or teaspoons may lead to increased happiness and harmony in the office.

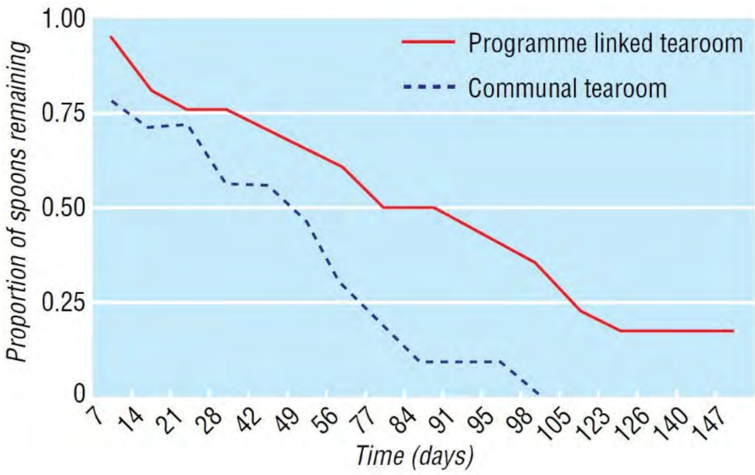

Figure 4: Proportion of teaspoons remaining by tearoom type (Lim et al., 2005).

Other studies focused on drinks and food routinely consumed in the workplace. Mayer and Krechetnikov (2012) investigated the annoying habit of coffee spilling out of its cup while the coffee drinker is walking, which is obviously a serious WHS concern. Using experimental physics, they studied the conditions under which coffee spills for various walking speeds and initial liquid levels in the cup (Figure 5). The motion was examined using an image analysis program written in MATLAB, while the instant of a spill was determined with a Light-Emitting Diode (LED) signal triggered by a sensor monitoring the coffee level in the cup. It was shown that the particularities of the common coffee cup sizes, the coffee properties and the biomechanics of walking conspire to be responsible for the spilling phenomenon.

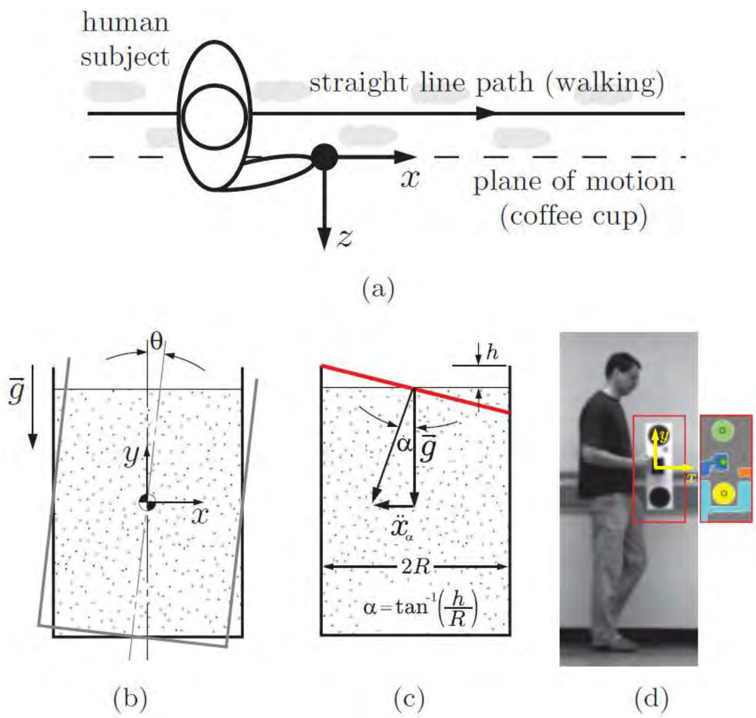

Figure 5: Definition and extraction of the cup dimensions and coordinates in the coffee spill experiments: (a) walking path as viewed from above, (b) plane cup coordinates (x, y) with pitching angle θ and gravity $\bar{g}$, (c) spill angle α and equivalent acceleration $\ddot{x}_\alpha$, and (d) MATLAB image analysis (Mayer and Krechetnikov, 2012).

Examining methods to reduce such spillage, Han (2016) suggested walking backwards (acknowledging associated WHS issues) or using the 'claw-hand' method of carrying the coffee cup (around the rim) to suppress the higher-frequency components of the driving force and thus stabilise liquid oscillation.

Chan (2007) reported on the Chocolate Happiness Undergoing More Pleasantness (CHUMP) study, which was designed to investigate the effects of chocolate consumption on happiness over a 1-month period. The 180 participants were randomised into three study groups. Group 1 received one 50 g dark chocolate bar each day, and group 2 received one 50 g milk chocolate bar each day. Group 3 did not receive any additional chocolate but continued with their normal chocolate-eating habits. Each participant rated their happiness before and after the study using a visual scale, along with their health and global happiness.

Data collection proved difficult, demonstrating the challenges of performing a truly blinded trial. Despite all efforts to the contrary, several participants changed groups mid-study. Some participants in the control group (who received no extra chocolate) started raiding the chocolate of those in the other two groups, while others in the dark and milk chocolate groups traded chocolate based on their individual preferences. The milk chocolate group was the most popular, increasing from 60 participants at inception to 82 at completion. Furthermore, the occurrence of Halloween may have resulted in crossover contamination as some participants increased their chocolate intake after Halloween by eating extra chocolate that was intended to be distributed to children or by raiding their children's loot bags. Not surprisingly, under these conditions, data analysis failed to prove the strong belief that chocolate consumption leads to more happiness. A far more important indicator of happiness in the CHUMP study appeared to be getting what you want when you want it.

For those dreading to attend the next work-related party, Armstrong (2020) presented a solution on how to maximise your positive impact on the social gathering and then escape discreetly as soon as possible. The procedure, dubbed Gradual Freeze-Out of an Optimal Estimation via Optimisation of Parameter Quantification (GFOOEOPQ), employs artificial intelligence and is based on Bayes' Theorem where the probability of a future model state depends on current knowledge of the model. First, the user completes the necessary interactions for making favourable impressions (or at least ensuring that these people later remember seeing them at the event) and identifies possible exits (including the density of people at these locations and the general flow rate between regions). Once enough data is collected, GFOOEOPQ (pronounced g^*fu*iːɔːp^kw) identifies the exit that minimises the chance that anyone notices how early the user snuck out. To achieve this, GFOOEOPQ employs a tempering procedure that iteratively arrives at the global optimum of a dynamic model, which remains valid only for a limited time due to the dynamic nature of the situation (i.e. "glance at the solution, glance over your shoulder, and then go for it or abort"). Tips for optimal interactions were also given, noting that the procedure can be generalised to corporate events and family gatherings if required.

4 VAMPIRES AND ZOMBIES

Humans have been interested in vampirology for a long time, presumably caused in part by the fear of potentially not being on top of the food chain. Applying serious analysis to an imaginary topic, several papers studied the coexistence of humans and vampires based on common predator-prey interactions but as a special case because the prey is turned into predator. Hartl and Mehlmann (1982) were the first of many economists to use mathematical optimisation and control theory to model a dynamic confrontation between the two species. Later, Strielkowski et al. (2012, 2013) modelled the human-vampire problem based on popular fiction literature, comic books, movies and TV series to determine whether peaceful coexistence of humans and vampires would be scientifically possible.

Despite not being part of the surveying curriculum anymore, astronomy remains an important field related to our profession, particularly in relation to satellite-based positioning on Earth and navigation in space. Günther and Berardo (2020) reported on the search for transit signatures of space vampires trapped in the gravitational pull of cool dwarf stars. This research supports the theory that vampires may have originated in outer space, settled down and domesticated asteroids, and then fell onto Earth through meteor crashes.

The authors generated models representing two potential space vampire populations (i.e. bat shape and humanoid shape) and searched light curves from the Transiting Exo-Vampire Survey Satellite (TEVSS) using a template matching algorithm. This clearly showed the distinction between the transit shapes of bats and humanoid space vampires compared to planets void of these creatures (Figure 6). Analysis of the TEVSS data provided a short list of between 0 and 394,400,933 potential space vampire transits. Using Bayesian evidence, they determined that two of these most likely originated from bats (or noise) and one from a humanoid shape (or noise), while the remainder could be due to either shape (or noise). Adding the information gained from TEvSS data constrained the space vampire occurrence rate to between 0% and 100%. It was noted that such precise analyses will be crucial in future observing schedules for space-vampire characterisation with the James Webb Space-Vampire Telescope (JWSvT) and the Extremely-Large-Vampire Telescopes (ELvTs).

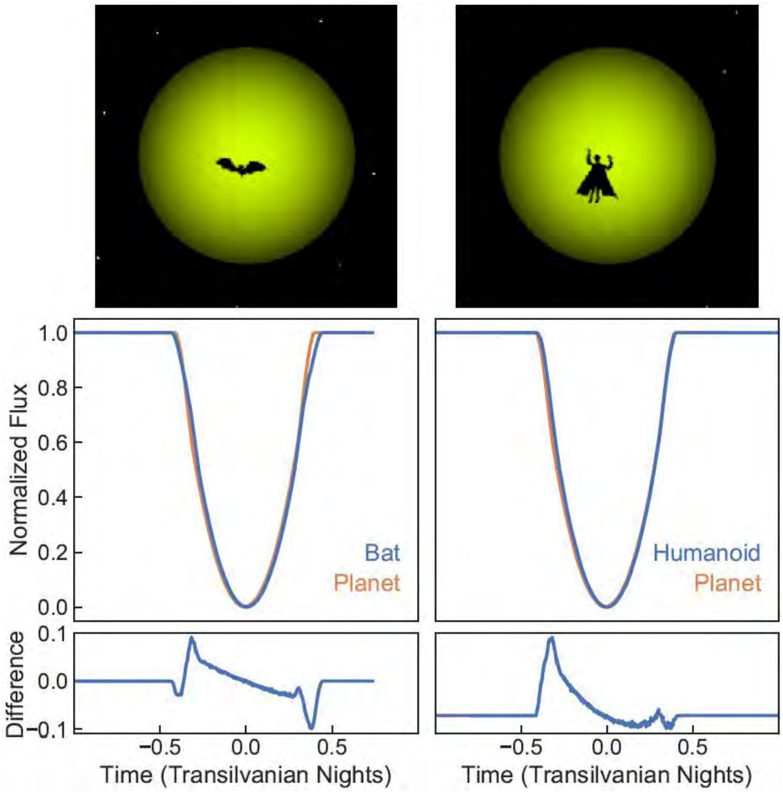

Figure 6: Transit shapes for a bat (left column) and humanoid vampire (right column) in comparison to a planet, showing the distinction between the three transit shapes (Günther and Berardo, 2020).

Due to their inferior intelligence and sophistication, zombies may not be as attractive to the science community as vampires. However, their insatiable hunger for living human flesh and ability to turn humans into zombies by inflicting a bite is an ideal setting to investigate scenarios of an infectious disease outbreak. Munz et al. (2009) were the first to apply mathematical modelling to the analysis of a zombie outbreak by using an epidemiological model to investigate the dynamics of a zombie apocalypse. Several others extended this work.

For example, considering several model variants and employing spatial parameters, Alemi et al. (2015) provided a full-scale stochastic dynamic simulation of a zombie outbreak in the United States (Figure 7). The simulation started with one in every million individuals being infected at random. By the first week, most of the population had been turned into zombies, although the map does not appear that compelling. In the early stages, the outbreak spread in roughly uniform circles, with the speed of infection tied to local population density. Infections on the coasts (higher population density) reached further than those near the centre of the country. After several weeks, the map shows stronger diversity in the directional spread, now over larger geographical areas and influenced by large changes in population density. After 4 weeks, much of the country had been overrun, but remote areas remained zombie-free even after 4 months.

Zombie danger maps were also produced, showing the probability of being infected at a certain location and point in time during an epidemic originating from a single zombie. As expected, after 7 days, high-population metropolitan areas are most at risk because many individuals could potentially serve as patient zero and zombies rapidly spread in these areas. After 28 days, it is not the largest metropolitan areas that suffer the greatest risk of being overrun but the regions located between them.

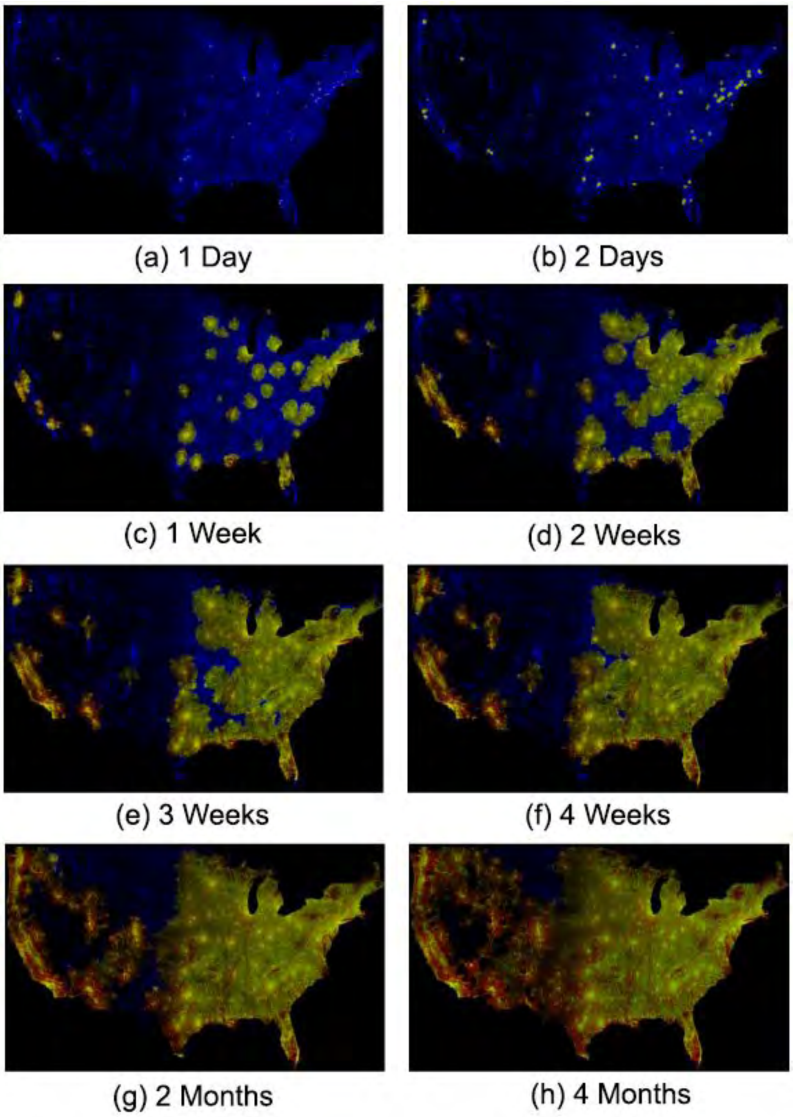

Figure 7: Simulation of a zombie outbreak in the continental United States over time, showing the uninfected human population (blue), active zombies (red) and the permanently dead (green) (Alemi et al., 2015).

These studies demonstrate the flexibility of mathematical modelling and how it can respond to a wide range of challenges for different areas of science, tongue in cheek or not. They also highlight that modelling output is heavily reliant on the assumptions made and the input parameters chosen. Amusing examples can improve student learning and make a topic more accessible to a general audience. Similarly, entertaining outreach programs can help attract potential students into Science, Technology, Engineering and Maths (STEM) and related disciplines. For example, Curtin University’s Team Zombie is a multi-disciplinary response team that investigates a zombie outbreak, models the spread and potential interventions, works towards cures or vaccines, and provides options for detection and monitoring. Engaging students from primary school through to university level, it is raising awareness of the many approaches to problem solving through models and simulations (Maxville and Sandford, 2020).

5 ANIMAL MAPPING AND ECOLOGY

Spatial tools are routinely used for animal mapping, ecology and conservation. Ecology is the study of the relationships living organisms have with respect to each other and their natural environment. McNoleg (1996) reported on several breakthroughs in the field of geomatics and demonstrated their application in a particularly difficult habitat mapping exercise for the endangered haggis. This 4-legged mammal is mainly native to the Scottish Highlands and unique because it has one pair of legs (either on the left or right side) that is shorter than the other pair. This evolutionary adaption allows it to easily walk around the very steep mountainous terrain in either clockwise or anti-clockwise direction, depending on its legs. Understandably, haggis have a natural aversion to any other plane of movement, preferring areas where the angle of slope is within a certain tolerance of the difference in height between opposite pairs of legs. After finding its niche, each haggis walks the same path around a hill for its entire life, creating an effect akin to a contour line (which can be visible in aerial and satellite images) due to soil compaction and the reduction in vegetation cover.

By substituting the traditional fuzzy logic image processing technique with misty logic (found more suitable for the environmental conditions encountered in Scotland), introducing a neural-network approach to evidence combination and adopting an innovative data structure hierarchy, the path for each haggis was modelled based on a combination of environmental, spectral, spatial, economic, temporal, taxonomic and astrologic data. A mathematical derivation (even the most outrageous ideas can look credible if expressed using complex symbology) showed that haggis habitats can also be located from geophysical data. Due to the forces at play when a well-fed, sodden haggis rolls downhill after losing its footing, its path can be detected as an extremely bright localised streak in gravitational anomaly maps and therefore be identified via image differencing. However, it was noted that no haggis tracks were detected despite the sophisticated analyses applied, leading McNoleg (1996) to conclude that the haggis is even more endangered than anticipated. On a more serious note, this paper also drew attention to the peer-review process and that some authors include large amounts of buzzwords in titles and (unnecessarily) complex mathematics to increase the paper's chance of acceptance.

Attempting to ensure the survival of the haggis (it is also considered a Scottish delicacy), King et al. (2007) pioneered the use of ultrasonography in its reproductive management and introduced new genetic material to improve the animal's welfare and productivity under farmed conditions. Selective breeding successfully increased body length, reduced hair coat, modified (drinking) behaviour, reduced seasonality and increased fank (litter) size. However, the uneven leg length remained a problem as it requires the provision of suitably inclined grazing.

By introducing genetic material from haggis native to the southern hemisphere via artificial insemination, they intended to produce even-legged haggis that could graze on flat land. The resulting fank contained nine hagglets with four being the desired even-legged variety of medium leg length, two exhibiting longer left legs, two exhibiting longer right legs, and one occurrence of the unexpected and worrying diagonally long-legged state (Figure 8). This state sometimes occurs in the wild where affected animals cope by grazing the sides of narrow ditches and streams with their two long legs in the water and their two shorter legs on either bank. It was emphasised that further research is required to prevent reoccurrence of this state under farming conditions and that the diagonally long-legged hagglet has been adopted by a lady in a Scottish village where it is living happily on a diet of hand-picked heather and Old Pulteney.

Figure 8: (a) Wild haggis with two hagglets on a steep slope, (b) farmed haggis and her fank of nine hagglets at two days old, and (c) two hagglets demonstrating the desired even-legged state (right) and the unexpected diagonally long-legged state (left) (King et al., 2007).

The use of Global Navigation Satellite System (GNSS) technology has been responsible for significant advances in the tagging and tracking of animals by providing accurate and frequent estimates of the changing distributions of many rare animal species. However, it is extremely difficult to apply conventional methods to the drop bear, a predatory Australian marsupial closely resembling the koala, which hunts by dropping out of a tree and skilfully latching onto the victim's neck to kill its prey. The dense tree canopy regularly causes extended periods of complete GNSS signal loss, and sensors are often damaged during attacks on prey.

Addressing this problem, Janssen (2012, 2013a) proposed an indirect GNSS-based approach by tracking the prey rather than the predator. Using bushwalkers equipped with GNSS and heavy-duty helmets to pinpoint the location and timing of drop bear attacks, he successfully estimated the number and spatial distribution of drop bears in the study area (Figure 9). This research also provided valuable insights into the animal's hunting behaviour, confirming that foreigners are much more likely to be dropped on than Australians and indicating that drop bears do not necessarily target the last person walking in a line. Fortunately, bushwalkers can protect themselves from drop bear attacks, e.g. by wearing forks in their hair, spreading Vegemite behind their ears or under their armpits, urinating on themselves, and avoiding talking in a foreign language or non-Australian accent. Drop bears may be identified by lying down beneath a tree and spitting upwards (a sleeping drop bear will most likely wake up and spit back). However, this method includes some risk, with potentially devastating consequences if drop bears are on the hunt for prey or in the middle of the mating season.

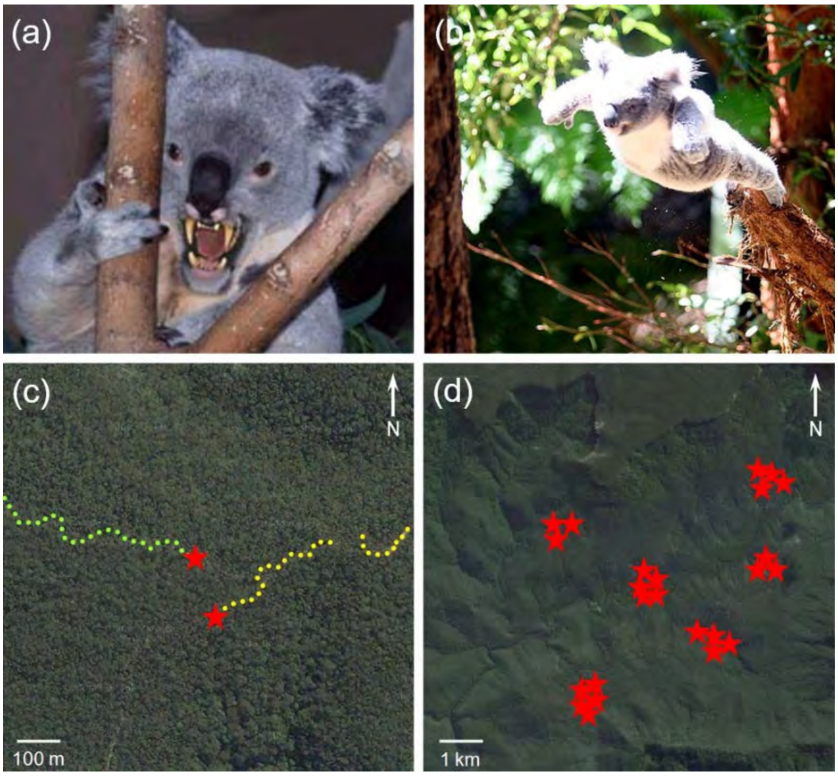

Figure 9: (a) Drop bear in its habitat, (b) drop bear attacking prey, (c) two GNSS tracks ending with a drop bear attack (denoted by a star), and (d) summary of all drop bear attacks observed (Janssen, 2012, 2013a).

The original journal paper (Janssen, 2012) was intended to demonstrate how a research paper should be written, that science can be fun and to increase awareness of GNSS technology (and drop bears, of course). These goals have been achieved, with the paper attracting much attention from Australia and overseas, including in the media (Janssen, 2013b). It quickly and unexpectedly became the most downloaded paper in the journal's online history.

Several other studies have successfully unlocked mysteries in the animal kingdom. Dacke et al. (2013) showed that dung beetles use the Milky Way for orientation. They experimentally determined that dung beetles transport their dung balls along straight paths under a starlit sky but lose this ability under overcast conditions. On a starlit night, beetles were released with their dung balls from the centre of a circular arena of levelled sand. This was repeated after obscuring the beetles' dorsal visual fields with small cardboard caps to prevent them from seeing celestial cues. Filming the beetles from above, their rolling paths were reconstructed and measured, clearly showing much shorter radial paths under clear conditions (Figure 10). In a planetarium, the beetles orientated equally well under a full starlit sky or the Milky Way only but took much longer when presented with only the 18 brightest stars or total darkness. Dung beetles therefore do not rely on a single bright (guiding) star but use the band of light representing the Milky Way for orientation, most likely not being able to discriminate individual stars.

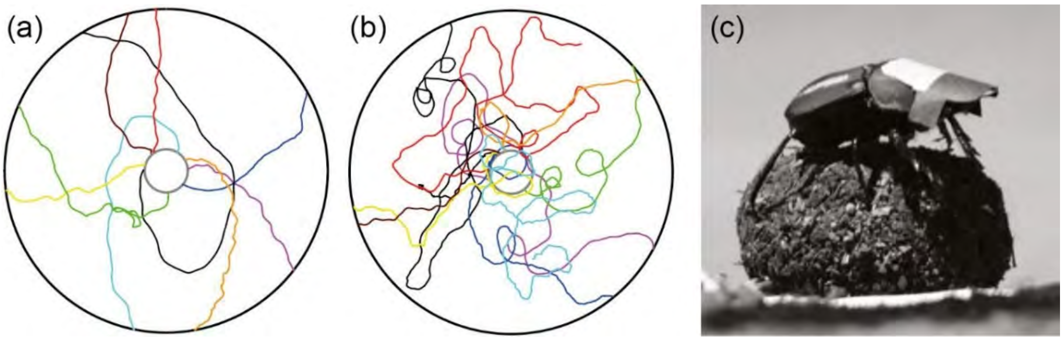

Figure 10: Paths of dung beetles rolling outward from the centre of a circular arena with (a) clear and (b) obstructed views of a moonless night sky, and (c) small caps attached to the beetle enabled blocking its view of the sky (Dacke et al., 2013).

Hart et al. (2013) demonstrated that dogs are sensitive to small variations of the Earth's magnetic field by measuring the direction of the body axis in 70 dogs of different breeds during defaecation and urination over 2 years (7,475 observations in total). The dataset was sorted according to the geomagnetic conditions prevailing during the respective sampling periods, and relative declination and intensity changes of the magnetic field during the dog walks were calculated. Circular statistics revealed that dogs preferred to excrete with their body aligned along the north-south axis under calm magnetic field conditions but abolished this directional behaviour under unstable conditions. The best predictor of the behavioural switch was the rate of change in declination, i.e. the polar orientation of the magnetic field, rather than geomagnetic intensity changes. However, it was noted that calm magnetic conditions occurred in only 30% of all cases.

In a more obscure example, Ghirlanda et al. (2002) determined that chickens prefer beautiful humans. By averaging 35 individual images each of males and females, average male and female faces were generated. A third face was obtained by averaging these two averages. Graphical image manipulation (linear extrapolation based on pixel patterns) was then used to create four additional faces, showing either exaggerated male or female traits, resulting in a set of seven faces increasing in femininity from left to right (Figure 11a).

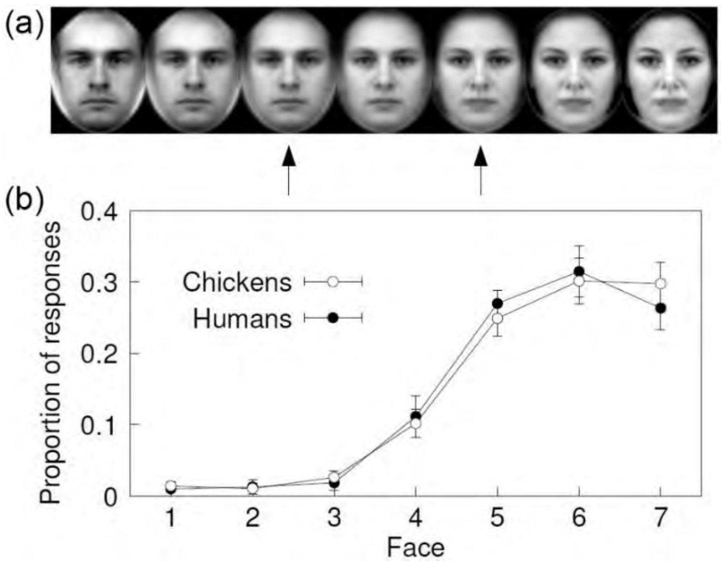

Figure 11: (a) Generated test faces with the average male and female face indicated by an arrow, and (b) average proportion of pecks by chickens in response to these faces along with human ratings of the same faces (Ghirlanda et al., 2002).

Biology students (7 males, 7 females) were then asked to rate all faces in random order according to how desirable it would be to go on a date with the portrayed person. The total scores collected by each face were transformed into relative scores, allowing comparison with animal data. Chickens (2 roosters, 4 hens) were first trained by being rewarded with food after pecking at the average male (hens) or female (roosters) face and then shown all seven faces at random. The results showed that human and chicken behaviour was almost identical (Figure 11b), thus proving that chickens prefer beautiful humans.

It is hoped that these important research efforts will continue, so we can further advance our understanding of the animal kingdom, allow animal conservation practices to be enhanced, and have some fun along the way. In particular, further research is required to fill the current knowledge gap related to mysterious animals such as the bunyip, hoop snake or gravel shark.

6 EXPLORING OUR PHYSICAL WORLD WITH TONGUE IN CHEEK

The laws of physics play a crucial role not only in surveying, mapping and geodesy but also in our general understanding of the world in which we work and play. Despite defying these laws, B. Volfson was granted a US patent in 2005 for inventing a space vehicle propelled by a superconducting shield, which alters the curvature of space-time outside the craft in a way that counteracts gravity.

This inspired Cyr and Lanthier (2007) to present a cost-utility analysis of abolishing the law of gravity. Using a hidden Markov model (a statistical model in which the system is assumed to be a Markov process with hidden unknown parameters), they estimated that 2 million quality-adjusted life years would be saved and determined the cost-effectiveness of adapting Volfson's anti-gravity machine for use on Earth. It was argued that a microgravity environment could have important positive impacts, such as stopping climate change by reducing fossil fuel use by 90% because cars would no longer be needed with transportation only required for overseas travel. However, they also noted that several negative side effects were ignored, e.g. extended microgravity exposure on the human body and technical problems related to the absence of gravity (including the use of wigs, intravenous fluids and toilets). Nevertheless, the study proved that a combination of technological, statistical and medical jargon can convince intelligent people to read a manuscript (and have a chuckle).

Noting that only a few legged species on Earth manage to run on water, Minetti et al. (2012) conducted experiments with humans running in place on water at simulated reduced gravity. They predicted the gravity levels required for humans to run on water (about 20% of the Earth's gravity) and tested these predictions using a reduced gravity simulator. Progressive body weight unloading of a person running in place on a wading pool confirmed that a person could run on water at lunar (or lower) gravity levels using small rigid fins. 3D motion capture of reflective markers on major joints revealed that humans keep the head-trunk segment at nearly constant height, in spite of the high stride frequency and the intensive effort required to move their body through space. These results showed that a hydrodynamic model for lizards running on water can also be applied to humans, despite the enormous difference in body size and shape.

Pedbost et al. (2009) identified a peculiar new class of galaxy cluster using data from the Galaxy Zoo project. It is well known that galaxies are not randomly distributed throughout space but tend to cluster together. However, it was a surprise to find several high-density clusters that are linear and box-like with individual galaxies approximating the shapes of letters in the modern alphabet. Although galaxies displaying morphologies corresponding to Latin characters have been noticed before (S and Z being particularly common), a localised collection of this size arranged in sub-groups was highly improbable. In one example, these shapes and sub-groups were interpreted as “we apologise for the inconvenience” (Figure 12).

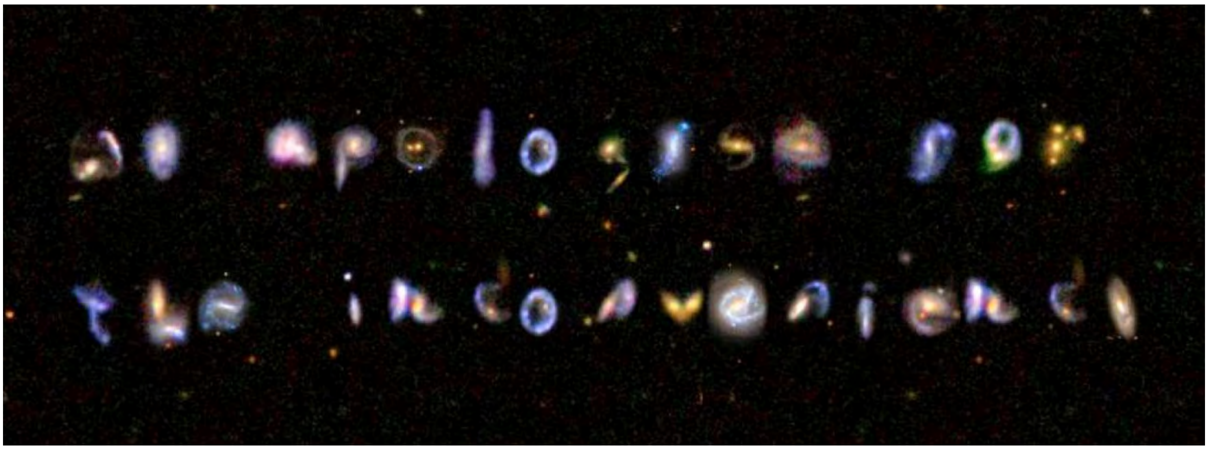

Figure 12: Colour composite image of an unusual galaxy cluster identified by Galaxy Zoo participants (Pedbost et al., 2009).

Noting that this may indicate the existence of intelligent extra-terrestrial life, the scale of the message would require a life-form with extraordinary powers. Two other clusters demonstrated additional features, including punctuation, capital letters, a numeral, an abbreviated unit and left-justified sub-groups, with messages interpreted as “caution! structure formation in progress” and “Delays possible for 7 Gyr”. When considered collectively, these appeared to suggest a common theme reminiscent of road works. This not only implies the existence of other intelligent beings (inconvenienced by said road works) but also may cause concern for Earth potentially having to make way for an intergalactic super-highway.

Armstrong (2012) reported on the non-detection of the Tooth Fairy at optical wavelengths. It appears that the Tooth Fairy obtains a child’s tooth with minimal difficulty and undetected, despite potential barriers such as bolted front doors and bad-tempered dogs. The only observational evidence of the being’s transient presence is the disappearance of the tooth and the small gift left behind in its place. Attempting to finally detect the Tooth Fairy, an optical 1.3-metre telescope was programmed to obtain an 8-hour time series of the author sleeping about 47 m away on the roof of the neighbouring observatory, with a freshly removed wisdom tooth under her pillow. At the end of the night, the wisdom tooth could not be located (neither could the pillow, which had tumbled down the sloped roof and come to rest against a tumbleweed).

Standard data processing failed to detect evidence of the Tooth Fairy. However, given the tooth’s disappearance, it was concluded that she indeed paid a visit. Preliminary evidence therefore suggests that the Tooth Fairy is transparent at optical wavelengths. The lack of a gift being left behind was attributed to the creature possibly feeling offended at this deliberate attempt to invade her privacy. Noting the limiting time resolution of 4 seconds for both the exposures and dead time between the observed images, the findings also indicate that the Tooth Fairy may be operating at much faster speed than previously assumed.

7 WORK HEALTH AND SAFETY

Peculiar and amusing research can also address important WHS issues and help improve our general physical and mental wellbeing. For example, Maguire et al. (2000) investigated the navigation-related structural change in the hippocampus (the part of the brain that is crucial for learning and memory) of taxi drivers. MRI brain scans of 16 London taxi drivers were analysed using 3D image analysis and compared with those of 50 age- and gender-matched people lacking such extensive navigation exposure. Although no difference was detected in the overall hippocampus volume, its structure in taxi drivers was found to be significantly different, and the regional distribution of its volume correlated with the amount of time spent as a taxi driver. This indicated that the hippocampus stores a spatial representation of the environment and can expand regionally to accommodate people with a high dependence on navigational skills.

Employing statistical analysis of various behavioural tests in addition to MRI brain scans, Maguire et al. (2006) later confirmed these findings by ruling out the potential influence of self-motion, driving experience and stress on the observed pattern of grey matter volume distribution in taxi drivers. This was achieved by comparing a new cohort of 18 London taxi drivers with 17 bus drivers who were matched for age, gender, education, intelligence, driving experience and stress level but differed in that they follow a constrained set of routes.

Consequently, head injuries are of particular concern to spatial professionals. Kamp et al. (2011) investigated traumatic brain injuries based on more than 700 head injuries occurring in the Asterix comic books. They performed a neurological examination for each head-injured character and correlated the clinical data with information regarding trauma mechanism (mostly blunt force), sociocultural background of victims and offenders, and the circumstances of the trauma to identify risk factors. Not surprisingly, the Romans suffered the most head injuries, mainly inflicted by Asterix and Obelix. Injuries were most severe when helmets were not used, emphasising the importance of wearing Personal Protective Equipment (PPE). Astonishingly, no character suffered long-term consequences or death. Characters who took the ‘magic potion’ caused significantly more severe head injuries, and administration of this drug after sustaining such an injury led to a prompt recovery.

Cyr et al. (2004) studied a unique case of delayed personal development. Tintin, the young reporter whose stories were published between 1929 and 1976, was about 14-15 years old when introduced (with the height of a 7- or 8-year-old), so would have been 60 years old during his final adventure. An exhaustive assessment of Tintin’s stories found that he suffered many significant head injuries causing unconsciousness. For each incident, they identified the cause of the trauma, the length of losing consciousness (calculated by the number of frames before Tintin returns to normal activity) and the severity of the trauma (indicated by the number of objects revolving above his head). Never did Tintin shave, grow taller or exhibit signs of pubertal development, suggesting that he suffered from growth hormone deficiency caused by repeated head traumas. It should be noted that the first two authors are the third author’s children, providing an excellent example of engaging young children with science.

Uncovering the mystery of what makes banana peels so slippery, Mabuchi et al. (2012) determined the frictional coefficient under banana skin using an experiment to simulate a slipping accident. Friction (or slipperiness) under banana skin was measured on a flat panel of linoleum floor and compared to a banana-free situation. A force transducer detected the applied forces in three dimensions at 100 Hz (Figure 13). They found that the tiny sacs of gooey substance lining the inside of banana skins burst when stepped on, forming a lubricated surface ideal for slipping. Compared to other fruit, banana peels were by far the most slippery. It was also shown that a banana skin is less slippery when the inside of the peel is in contact with the shoe because the irregularity of the shoe sole tends to break the lubricating film. A follow-up paper provided further information and explained the connection to mucus, based on the similarity of the lubricating function in banana peels and the joints of a rabbit (Mabuchi et al., 2016).

Figure 13: Experimental set-up to measure the friction coefficient under banana skin and the coordinate system used (Mabuchi et al., 2012).

Shah et al. (2011) compared the travel time between hospital floors using stairs or elevators. Four people aged between 26 and 67 years completed 14 walking trips each, ranging from one to six floors both ascending and descending, and a total of 336 elevator trips. Statistical analysis determined that the mean travel time between floors was 13 seconds by stairs and 36.5 seconds by elevator, the difference being caused by waiting for the elevator's arrival. Not surprisingly, elevator travel time varied depending on the time of day and day of the week. All participants were able to continue their duties without resting after taking the stairs, so fatigue was not an issue. Acknowledging the small sample size, it was concluded that taking the stairs can save 15 minutes each day, which could translate into improved productivity and fitness. Although spatial professionals may be making fewer trips per day, this should encourage us all to use the stairs whenever possible.

In a very timely contribution, Chapman and Thamrin (2020) characterised how the working arrangements and productivity of Australian medical researchers changed during the COVID-19 pandemic, with particular attention to wearing pyjamas. Over a 3-week period, 160 staff and students at five medical research institutes in Sydney self-assessed their productivity and mental health. The most frequent working-from-home arrangements were the kitchen or dining table (42%), followed by individual (28%) or shared (22%) home offices, while five respondents (3%) resorted to working in their bathroom. Interruptions to teleconferences included internet problems, children, other household members, pets, the doorbell, phone calls, toilet breaks and one instance of sleepwalking. Only a few participants confessed to wearing pyjamas while working, which was not associated with lower productivity but linked with poorer mental health. People working at home with young children reported lower productivity but no deterioration in mental health, and early career researchers were less productive than established researchers. Hopefully, these findings will help remove the stigma attached to wearing pyjamas during work hours and improve flexible working policies. A broader promotion of National Pyjama Day in the workplace may be a good starting point in this regard.

8 SURVEYING PRACTICE EXAMPLES

Occasionally, weird and wonderful things also occur in surveying practice. There are tales of surveyors enduring an arduous journey to a concrete-pillared trigonometric (trig) station for a GNSS survey but forgetting to bring a tribrach, which resulted in applied bush mechanics and an antenna height of zero. Others reached a trig following a lengthy and rather challenging 4WD access only to discover that a brand-new bitumen road had been built right to the top on the other side of the hill. Then there are those who successfully finished observing and painting the trig but may have been a little overzealous during the rough 4WD trip back down, inadvertently painting the inside of the truck's canopy in the process. Others were just about to hop out of the vehicle after it came to a stop in front of a closed gate as a speeding emu crashed into their door. With the emu simply shaking its head in surprise, leaving a pile of feathers and running off, you can imagine the difficulty to explain the huge dent left behind to their manager. Some may have found their trig easily enough and without incident but did not expect it to be decorated appropriately for the season (Figure 14). Others ended up becoming the talk of a small rural town because they transported their survey gear around in a borrowed wheelbarrow for a week while waiting for a vehicle replacement after a failed river crossing attempt – certainly a walk of shame, but their dedication to finish the job was admirable.

Figure 14: TS3663 PANORAMA in Christmas mode (courtesy of Nic Gowans).

In the cadastral realm, the importance of key boundary marks and reference marks in maintaining a sound cadastre cannot be stressed enough. However, some surveyors may have taken this a little too far, with instances of two or even three GI pipes being placed at the same location (Figure 15), thus confusing several generations of surveyors. Some survey plans include unusual notations, providing excuses for certain lot corners not being marked due to the ground being too steep or too hard, the presence of large dogs or a hostile occupant (Figure 16). There is also evidence that trees were sometimes marked with a 'dickie hole' in the old days, which apparently is a technical description (Figure 17).

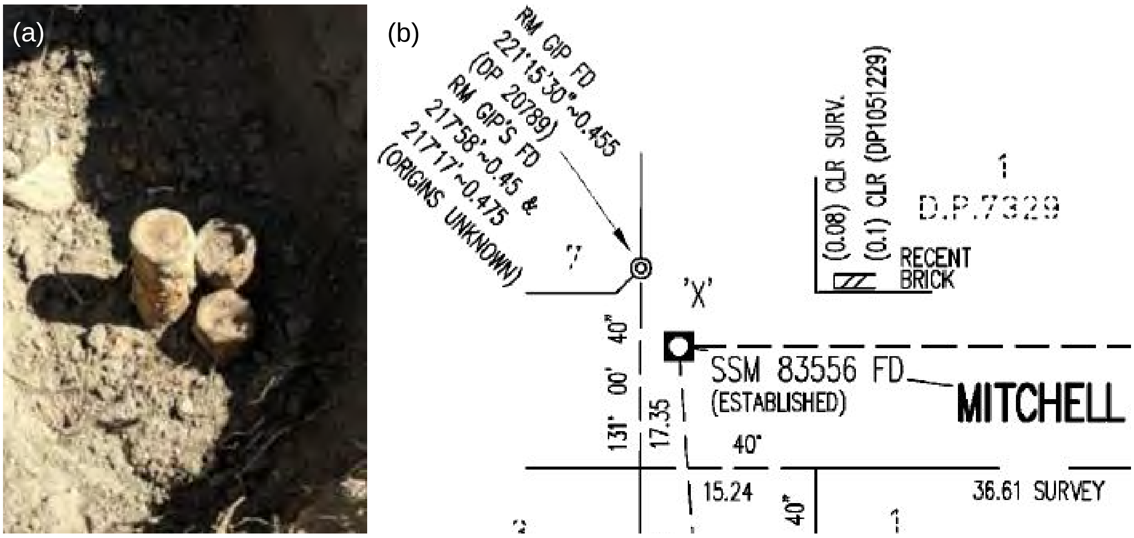

Figure 15: (a) Three GI pipes referencing a single corner (de Belin, 2018) and (b) extract from DP1246370 showing these on the plan (de Belin, 2021).

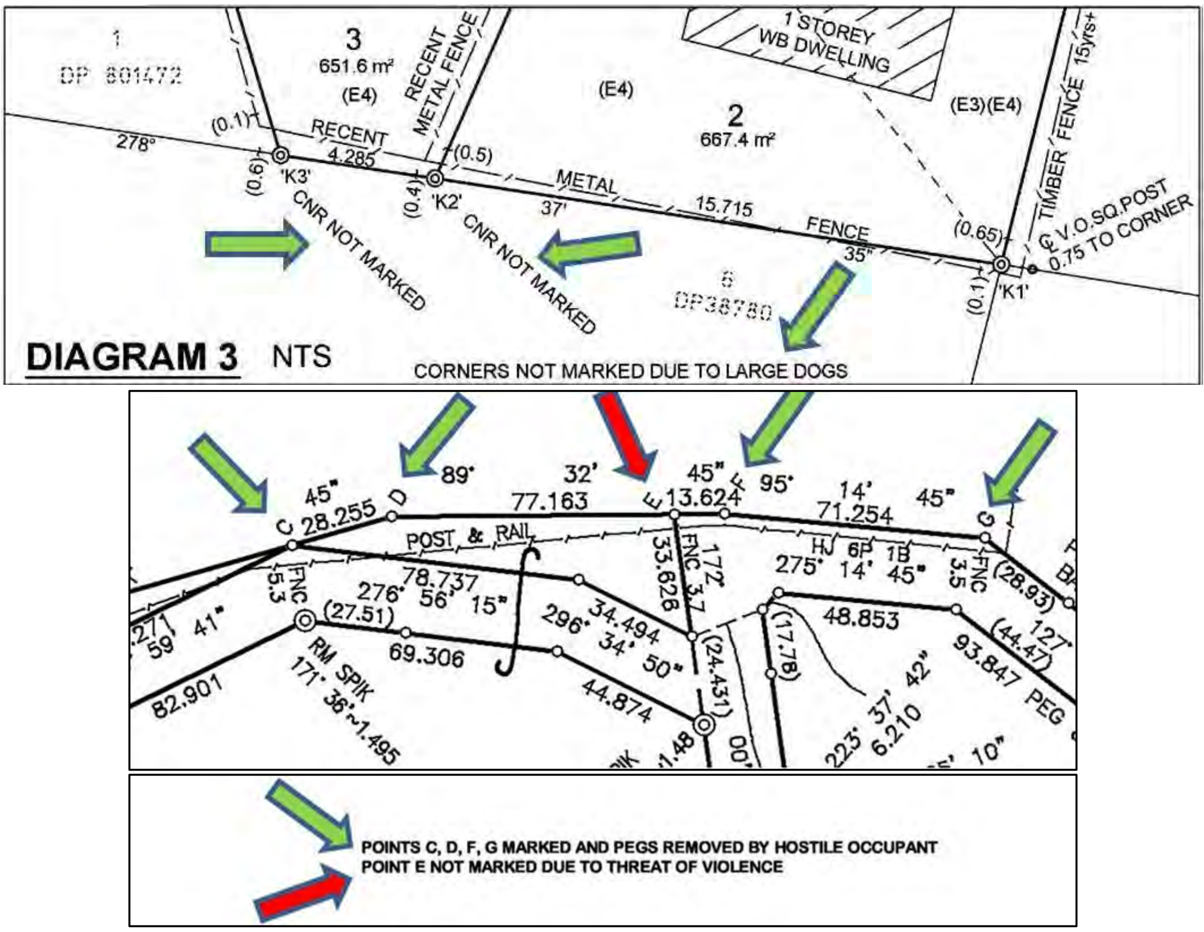

Figure 16: Corners not marked due to large dogs or intervention by a hostile occupant (de Belin, 2021).

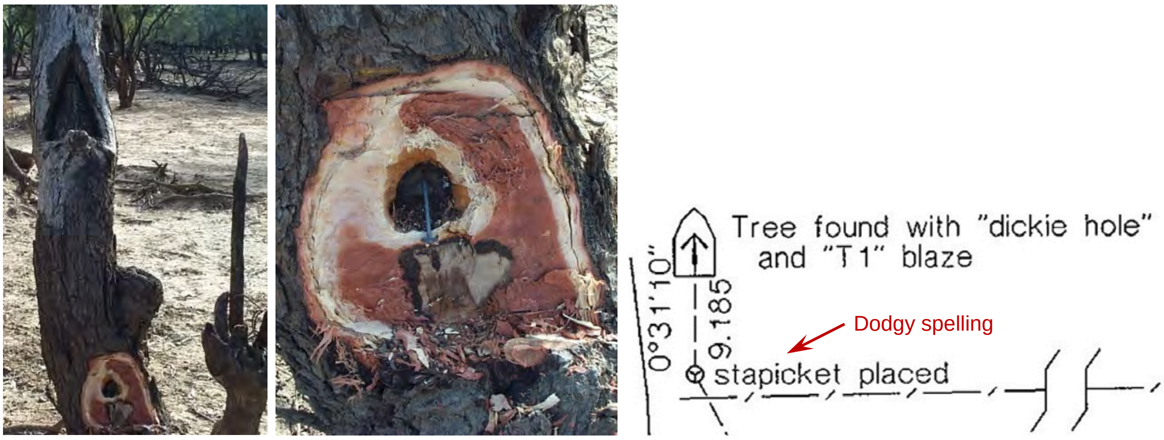

Figure 17: Tree with 'dickie hole' and its description in the Locality Sketch Plan of PM142268.

Finally, it is acknowledged that GNSS technology has been responsible for substantial advances and improvements in the surveying industry. However, it is important to note that GNSS is not the solution for *everything*, and surveyors should remember the other tools at their disposal when attempting to observe certain survey marks (Figure 18).

Figure 18: SS101605, not a particularly good GNSS site.

9 CONCLUDING REMARKS

In an age of increasing importance of high-quality, peer-reviewed research output by academics ('publish or perish'), it would be a shame to lose the funny side of science as it is also a crucial part of academic freedom. Thankfully, several journals continue to support the publication of the occasional humorous paper. Unusual and imaginative research is also being honoured through the Ig Nobel Prizes, which were introduced in 1991 to make people laugh and then think, spurring their interest in science along the way. In a world still suffering from the effects of the COVID-19 pandemic, maybe this is now more important than ever.

This paper has provided an introduction into the fascinating world of amusing research related to surveying and the spatial sciences, addressing general issues associated with publishing and presenting, typical problems encountered in the workplace office environment, the contribution of vampires and zombies to science, innovative approaches to animal mapping and ecology, attempts to explore our physical world, WHS issues and our general wellbeing, as well as highlighting some examples encountered in surveying practice. It has demonstrated that science humour not only plays an important role in improving student learning and the general public's understanding of science, but also contributes to increased happiness and harmony in the workplace. Thinking outside the box is very much encouraged!

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Don’t Feed Cheese to Lactose Intolerant Volcano Gods

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ABSTRACT

This paper looks at the many times we’ve been told “that won’t work because we’ve always done it this way” in education. Which we ignored, largely because we weren’t the ones that tried and, more importantly, because sometimes it’s just about feeding cheese to lactose intolerant volcano gods and waiting to see what happens. From monster trucks to escape rooms, dinosaurs to scavenger hunts, and X-Men to Lego, we take a journey through some of the weird and wonderful ways that we’ve tried to make surveying and engineering education not just more authentic, but also engaging without compromising curriculum. In some cases we’ve had success, and in others we’ve taken a few attempts to get it right. And in some cases, we’ve ended up needing to convince security guards at international airports that our students are honestly doing an assignment about zombies.

KEYWORDS: *Surveying education, students, pedagogy, first-year experience.*

1 INTRODUCTION

Universities spend a significant amount of time, energy and money recruiting students, and retaining them is a high priority. Across Australia, the average attrition rate for universities was 20% when measured by the Tertiary Education Quality and Standards Agency back in 2017 (TEQSA, 2017). Universities are implementing different approaches to try and lower this attrition rate, and at the University of Southern Queensland (UniSQ) one of those approaches was the First Year Experience project, as part of a larger-scale strategic academic plan. This is where the authors come into the picture, as the “First Year Experience Leads” for their respective schools, i.e. Surveying & Built Environment, and Engineering.

This paper isn’t a traditional academic paper (referencing isn’t our idea of a good time!), but it does seek to layout some of the weird and wonderful things we’ve attempted over the years in an effort to make the education of surveyors and engineers more successful, and most importantly, fun.

With that, welcome to possibly one of the strangest conference papers you are likely to read, inspired in part by the infamous drop bear paper by Janssen (2012). While we’re a surveyor (Chris) and an engineer (Catherine) first, we’re academics second and that means a whole other lexicon that we need to drag you into, so let’s get the boring stuff over with upfront so we can get to the good stuff.

Pedagogy is defined by dictionary.com (2023) as the "method and practice of teaching, especially as an academic subject or theoretical concept", but really it boils down to all the stuff that's involved with how we teach, both in practice and in theory (because nothing every quite goes to plan!).

While there are some main classifications of pedagogy, it's kind of like a pair of jeans – everyone has their own different style and preferences as to what works for them (and their students). The key component of pedagogy is that it is constantly evolving based on experience, knowledge and skills, not unlike all those other professional skills a surveyor and engineer might need.

Educating surveyors and engineers can be a challenge at the best of times – it's a mix of trying to get some serious maths and physics onboard (not necessarily with any context), while also trying to get a vast foundation of technical concepts down, along with building all the required skills of being a student. It is not unlike being a parent and trying to get your kids to eat vegetables at times. So, the value of a pedagogy that can make that education engaging, authentic and not compromise the curriculum is worth its weight in (pirate) gold.

Any educational course has three main components: Learning Outcomes (LOs) that must be delivered, assessment to measure how much of the LOs have stuck, and Teaching and Learning (T&L) activities that are 'the lecturer and students do things' part. It can be very easy for these things to become disconnected without deliberate design. There are any number of approaches on how to stop this disconnection, but the main one that underlines all the work discussed in this paper is the one that focuses on *how* and *what* students learn. In academic speak, it's a pedagogical design approach called 'constructive alignment'. The constructive part is the *how* (students constructing their knowledge through learning activities), and the alignment part is the *what* (the assessment and T&L activities must be deliberately aligned with the learning outcomes). In this paper, it is our pirates' gold that underpins all the weird and wonderful things we are discussing.

Before we start, it is worth noting that we are lucky to have a number of amazing colleagues who are not lactose intolerant volcano gods and genuinely engaged with our ideas and helped us bring them to fruition. We are really grateful for that. The larger audience, however, was not quite as receptive to our even moderately edgy ideas…

2 MAKING IT MODERN: SLACK & PADLET

2.1 The Issue

Universities are not unlike other large organisations. There are a huge number of systems in the background that support the business needs. The key outward facing one at UniSQ is the Learning Management System (LMS) called StudyDesk, based on the open-source system Moodle. Each delivery of each course has its own StudyDesk, and this is the one-stop-shop for students for all course materials and assessment. StudyDesk also offers a couple of communication and collaboration methods, such as forums (think early 2000s message boards) and direct messaging. Neither method is particularly user friendly and, more importantly, does not provide a method of students being able to access help when they need it.

The idea behind forums is great, but the execution is outdated in this age of instant messaging, emojis and GIFs. We have found that students don't engage particularly well with them, despite our best efforts. From our perspective, this presented a real problem. We know engagement is a key indicator in the success of a student in a course, but the communication and collaboration methods we had as a default were a barrier to that engagement.

2.2 The Cheese (aka the Solution as We Saw It)

A good proportion of our students have grown up with computers, and most have access to messaging and collaborative webservices or apps in their day-to-day lives. We set about finding some in the sea of apps that would be useful for both communication and collaboration. Our main criteria was that there would be no cost barrier for students to use them. Enter Slack and Padlet.

Slack is an instant messaging program that lets teams or communities of people come together in one place, and allows for 'channels' of communication, file sharing, emojis (including custom ones if you're so inclined) and a host of add-ins that include Google, calendars, polls, and our personal favourite, GIFs. It can be installed on phones, tablets and computers alike.

Padlet is like a virtual wall that you can cover in content-rich sticky notes, from photos to URLs and from slideshows to music – the possibilities are endless. It lets you drag and drop things around as needed to meet whatever organisational requirement you have at the time. Like Slack, it is also available across all platforms.

Both of these apps would allow us to address the concerns we had around communication and collaboration barriers, and we implemented them in our courses independently – Chris used Slack, and Catherine used Padlet.

2.3 The Lactose Intolerant Volcano God (aka the Problem with Our Solution as Told to Us by Others)

As with anything new, particularly in the world of Intellectual Property (IP) and IT departments, we were met with a wave of reasons we couldn't/shouldn't use Slack and Padlet.

"It's outside of official University systems", "ICT will never sign off on it", "You'll need to get permission and it'll take years", "The students will hate it and you'll get bad course results", and "The students will lodge official complaints" were just a few of the reasons we heard.

Thankfully, neither of us are particularly good at asking permission when we believe in something – we're much more in the ask forgiveness camp. But we are also not completely reckless, so we did a significant amount of research to ensure we would have an approach to give us the best chance of success, and also so we had safeguards in place to keep us and the students safe. For example, the two key safeguards in Slack were always ensuring another academic was present in the application, and that students could only participate or join up using their student emails.

2.4 Throwing the Cheese into the Volcano (aka the Results of Implementation)

Slack was implemented initially in a first-year course in 2019 and based solely on the volume of messages produced by students it could be considered a success. Over 3,000 messages were sent across 12 channels, compared to approximately 400 forum posts for the entire semester in the 2018 delivery. Both years had a cohort of approximately 150 students.

The key learnings from the initial use were:

- The use of GIFs and emojis provided the opportunity for students to express context and emotion, which can often be a challenge in a text-based application.
- 12 channels were too many, students were often confused about what to post where.
- Students with higher levels of messaging tended to do better in their final grade, confirming the previous understanding of engagement being a key success factor.

Since that first implementation, Slack has been used in 20 different deliveries of different courses, across all year levels. It has not always been smooth sailing though, and the presence of a couple of strong personalities can take things sideways if not carefully handled (although this is also the case in the traditional forums). There has only been one instance of a Slack needing to be discontinued during the semester due to communication issues, when we went back to forums.

Padlet has also been a success across a variety of courses, allowing students to collaborate and organise their ideas and learning in real-time, and also engage asynchronously when the time is right for them. We have also used it successfully for staff training sessions and workshops (Which minifig are you?) and orientation (scavenger clues and photos). It recently released its slideshow mode, which we think makes it a serious contender with PowerPoint, but with some added advantages, such as accessible from anywhere, interactive and the ability to embed documents.

3 MAKING IT FUN: ZOMBIES, SCAVENGER HUNTS & ESCAPE ROOMS

3.1 The issue

Unfortunately, it is easy for things to be boring, and this is never truer then when it comes to technical materials, content and assessment. Let’s be honest for a second and acknowledge that there are parts of our jobs that are mundane – surveyors will peg out endless numbers of engineering works and engineers will forever get sick of surveyors telling them their designs don’t fit! There is a lifetime of a career in front of students to experience that, but there is zero reason why their learning needs to be boring.

We had to address this issue in two key areas, i.e. orientation (because who really wants to hear a bunch of professors with long titles talking *at* you) and assessments (because measuring the three corners of a triangle five times in a row is boring to do, boring to write about, and boring to mark). Neither were engaging, let alone fun, and neither were achieving their key deliverables.

3.2 The Cheese

The main opportunity of this particular piece of metaphorically stretched cheese is that we could make stuff fun and engaging, while also achieving the key outcomes. For orientation, it meant moving away from the parade of professors to a meaningful engagement with staff and students, along with some defined Key Performance Indicators (KPIs). Students needed to know some key people and key locations on campus and online, and they needed to know how to survive their first few weeks. Ideally, they’d have met at least one person they’d see in class.

Initially the idea of an escape room was thrown around, but the logistics of delivering it in a short time frame meant we shelved it (for now). The next idea was the one that stuck – we needed a hybrid version of a scavenger hunt that took students to meet key people, see key locations and learn the handful of things that they needed to have a successful first week.

For assessment, it meant making sure we were balancing the required LOs, reducing the opportunity for Academic Integrity (AI) issues (cheating) and making it interesting. The course in question was 'Introduction to GPS', where students are learning about the basics of Global Navigation Satellite Systems (GNSS), so we also needed to reduce technological barriers (access to GNSS units) and ensure students could participate wherever they might be on the planet (one student was deployed in the Navy).

In the wee hours of the morning (probably after too much marking, an episode of The Walking Dead, an abundance of caffeine and not enough sleep), the idea to present students with a zombie survival scenario was hatched. Students would be able to use an app on their phone no matter where they were, they would need to visit five locations that met their survival needs, and they would need to make a 'Survival Manual' explaining how GPS worked to a layperson, to be used in the event the student got turned into a zombie.

3.3 The Lactose Intolerant Volcano God

The volcano gods were most displeased with us over these two pieces of cheese. Suggestions about the childish nature abounded when we suggested that orientation should be fun and engaging, and not involve three hours being talked at in a lecture theatre. The most common question was how we would make sure students knew all the minutiae that was in the information dump that orientation was, which in reality was probably all but forgotten as the students exited said lecture theatre.

"Zombies are completely unprofessional and childish. How will the students see that as relating to GPS?!" said another when reviewing the first zombie assignment. One even told us it couldn't be educational if it was fun. Largely the feedback on both ideas was of the same theme – it was breaking out of the "we've always done it this way" comfort zone. At this point, please refer back to our earlier statement about permission and forgiveness. At least orientation had the backing of our Heads of School, so we had our chance to show the doubters it could work.

The other concerns around orientation that were raised were legitimate: How much would orientation cost to do this way? Do we have the skills to organise an event like this? Do we have the people to pull this off? What would the students think? We weren't sure of the answers, but as women in Science, Technology, Engineering and Maths (STEM), we're not strangers to a challenge (we will even admit to seeking them out), and we had a goal and a deadline, so began the hard work.

3.4 Throwing the Cheese into the Volcano

Let's start with the zombie assignment. It was a hit on all fronts – largely due to the options we gave students around their submissions. Reports, videos, presentations and other forms of submission would all be accepted, the only restriction was that interpretive dance was only acceptable with a supplied interpreter to explain it to us. Not only did the students get into it with Snapchat filters, makeup and costumes, but they also wrote short stories, an act of a play, did David Attenborough style YouTube videos and made amazingly awesome and clever GNSS memes. They went above and beyond the scope of the assignment, and many even pondered the longevity of GNSS in a zombie apocalypse world. Most importantly though, their marks (and eventual grades) indicated a level of learning that broke the bell curve, in the good way.

We have continued to run the zombie theme in this course for 5 years now, and it has begun to develop an infamy that might be hard to get away from – we have overheard first year students asking each other if they'd done "the zombie subject yet". Maybe pirates might need to make an appearance in the future…

Orientation has been very much a case of having a goal and a deadline and not sleeping very much. It has been an iterative process – the first delivery was too intricate and relied on very specific timing, which of course was out the window in the first 30 minutes. Other versions have seen diabolical weather slow down our timelines, meaning lunch was cold, key staff being out sick, as well as all the other challenging things that happen in any event. Despite all these glitches, overall, it has been a real and significant success, to the point that it is now being rolled out as a university-wide model for orientation.

The key learnings we have taken from it so far are:

- Knowing what the key outcomes are up front is critical – and not being afraid to question if the key outcomes you are working towards are the ones you *should* be working towards.
- Having backup resources and staffing is key to it running smoothly.
- Letting others help is important, but the underlying philosophy must be non-negotiable.
- You can do a lot with almost no budget if you are creative – cute plastic dinosaurs can be used as an icebreaker, a prop for scavenger hunt photos, and as Chris discovered at a residential school, a great quality control tool for knowing which group set up which GNSS unit based on the type and colour of dinosaur in their photos.

4 MAKING IT REAL: EXAMS SUCK, WE'D RATHER BE DOING STUFF

4.1 The issue

Well before the COVID-19 pandemic threw the proverbial spanner in the works, we were already on the road to phasing out exams in certain courses. Invigilated exams are excellent for academics in terms of marking time being minimal as you do not need to provide feedback, and they make it very hard to cheat. However, they are generally not a useful technique for students to understand where the deficiencies in their knowledge are, and they can disadvantage neurodivergent students, such as those with Attention Deficit Hyperactivity Disorder (ADHD), anxiety, Autism Spectrum Disorder (ASD) and Specified Learning Disorders (SLDs) such as dyslexia. Surveying and engineering students are generally hands-on people, so this also presented the opportunity to get them doing stuff instead of just writing about doing stuff.

4.2 The Cheese

As with the zombie assignment discussed in the previous section, the main opportunities in replacing invigilated exams with assignments was to make them relevant to a student's location and life experiences, make them personalised to minimise academic integrity issues, make them hands-on and practical where possible, and, of course, to make them fun.

The type of 'cheese' in this situation varied depending on the course it was a part of, but the common theme was that they all followed the 'constructive alignment' approach. We wanted students to take the knowledge and skills learned through a course and use them in their assessment, making sure that assessment was open ended and personalised where possible. As an example, students were regularly given options in the way they wanted to present the required information – recordings, interviews, models, designs, reports and presentations were common methods. To ensure we did not completely blow the marking timelines out of the water, we put some general guidelines in place, including word counts, interview lengths, number of slides and length of recording.

4.3 The Lactose Intolerant Volcano God

Increasing the marking load of an academic (volcano god) is a guaranteed way to get at least some fiery bursts of lava. The most common concern lay around having to mark personalised assignments, particularly where there are calculations or computations involved. Providing feedback is very time consuming in these cases, and consistency of marking can be difficult without an appropriate rubric, which takes skill and time to develop. Thankfully, COVID-19 broke the stranglehold on this one, helped along by some specific direction from the higher levels of the university.

4.4 Throwing the Cheese into the Volcano

There were the predictable teething issues with moving away from the habit of invigilated exams: the limitations of software to do what we needed efficiently for marking and grading, academic integrity cases for new assessment that hadn't had the years of refining that exams had, submission glitches and just the basics of having everything set up correctly considering all the moving parts.

The biggest benefit in redesigning our assessment has come from the engagement with various parts of our respective professions. It tuned out one of the simplest ways to identify the knowledge deficits was to speak to the people who were dealing with the issues that were resulting, i.e. our colleagues in government and private industry. Within the scope of specific courses, we managed to quickly identify the areas that were being missed in the design of course activity and assessment, and we were then able to design targeted, authentic, real-world focused assessment to address them.

In time, we have been able to refine these styles of assessment, while also getting more creative with them – some courses have implemented a 'choose your own adventure' style assignment to allow students to personalise their work. This in turn has minimised the academic integrity issues.

The other benefit of these style of assessments has been the implementation of more consistent assessment instructions and materials. Assignment briefing documents are more detailed in the first year, giving quite explicit instructions about what is expected in terms of reporting and response, while later years much of the non-technical instructions are removed as students have more experience in what is expected of them (in academic language we call this scaffolding). The marking rubrics that provide students with information on what is a high-level response through to a poor response are also more consistently implemented across courses and assessment items. These rubrics allow students to know when they are 'done' answering an assessment piece, and the expectations around achieving different levels of marks.

The benefit of this has been evident in several key first-year courses. The progression rates of two key surveying courses, SVY1110 Introduction to GPS and SVY1104 Computations A, are shown in Figure 1, where a significant increase in progression after assessment redesign is evident.

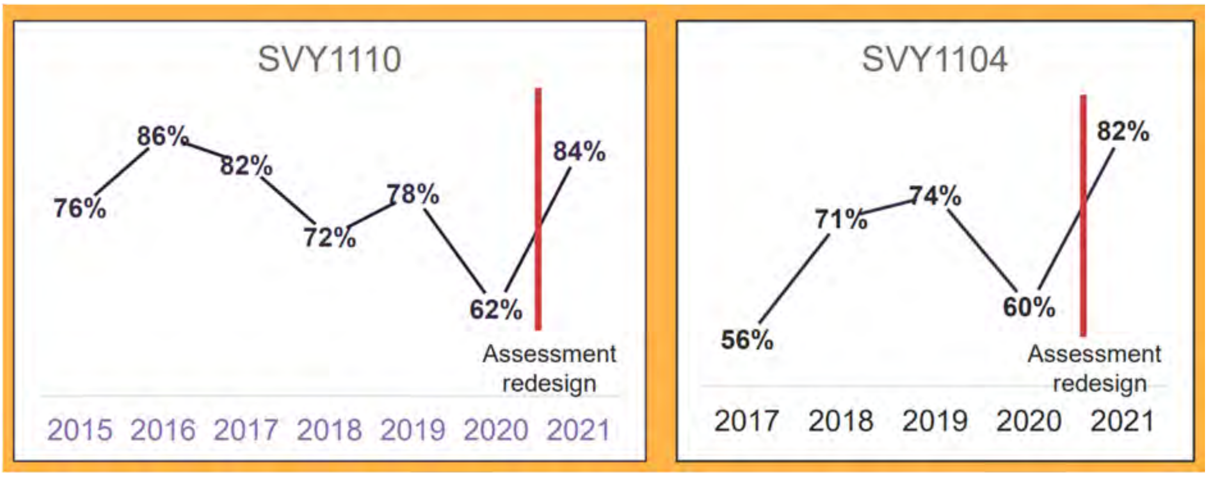

Figure 1: Results from two key surveying courses, indicating progress rates before and after assessment redesign.

5 MAKING IT PERSONAL: PROFESSIONALS CAN WEAR DINOSAUR T-SHIRTS

5.1 The issue

We all have our own perception of academics, and that will usually involve some combination of the following adjectives: remote, aloof, genius, picky, judgmental, scary, standoffish, cranky, boring, tweed coat-wearing and superior. While the reality is obviously more complex, these perceptions of academics often mean that students feel they are unable to approach a lecturer for help or clarification. That is a significant problem in terms of teaching and learning activities being successful.

5.2 The Cheese

In our first few years as academics, we heard a lot of conversations around how to get students to be authentic, and how to get them to engage with lecturers. The part of the conversation that was missing was what motivation students had to be authentic with us – it was akin to asking them to trust us with no evidence of why they should.

This led us to the somewhat obvious conclusion that if we weren't authentic with them, we couldn't expect them to be authentic with us. What authentic looked like in terms of an academic was a harder proposition, and the literature was relatively quiet on the attributes of a 'good' lecturer, let alone an authentic one. In the absence of study-based evidence, we set about talking to our colleagues and students to get some anecdotal evidence on what authentic looked like.

The responses were varied, but we identified that along with knowledge of and confidence in the course content, staff (particularly in first year) should consistently demonstrate the following attributes when dealing with colleagues and students:

- Friendly
- Approachable
- Empathetic
- Supportive
- Organised
- Flexible and responsive to student needs
- Excited about the course
- Demonstrating best practice teaching & learning
- Open to constructive feedback and prepared to innovate
- Team player

Further to this, we then proposed a suite of training for staff who teach into the first year, in particular courses with head start (high school) students enrolled. Ideally, the training courses should include:

- Supporting students in distress
- Supporting students' mental health
- Blue card (working with children check)
- Core inclusion training course
- Disability inclusion
- Indigenous inclusion
- LGBTIQ inclusion
- Teaching & Learning (T&L) induction
- Assessment essentials
- MATE – bystander program
- Neurodiversity awareness training
- Empathy training
- Emotional intelligence development
- Basic developmental psychology

We realised that upskilling staff to this level would take some time, so we proposed that initially all teaching teams should include at least one person who has completed each course or has prior experience in a course area. Not all of these courses exist yet either, so we are doing our best to keep these on the radar!

5.3 The Lactose Intolerant Volcano God

This approach was a fairly significant change in approach for some academics. Some argued that they needed to maintain authority as the lecturer and being distant and aloof was part of that persona. This goes hand in hand with the "I am the lecturer, I know everything and must always be right" philosophy that we personally find even the thought of exhausting. We argue that by showing students how you authentically work through a problem, and perhaps make mistakes, is a much more useful learning tool than reusing the same pre-prepared exercise you have run through the same way every year for the last decade. Remember that students are learning the process, and the outcome for them is not just the result but the incidental learning that happens when we approach problems authentically. In the same theme, it was also floated that being authentic was not professional – one must have different personas for your professional and personal lives. Thankfully, many academics embraced the idea of being authentic, giving them a framework to continue and extend what they were already doing in their courses anyway.

Perhaps the best argument for authenticity in educational settings is that it helps to make it fun. It is a way to introduce a relevant bad joke, share an industry experience that demonstrates why this concept is really important, empathise with students because you may have also found this or that concept difficult, and share strategies. While the argument can be made that being an academic does not excuse one from the requirements of professional development, it can be a fine line to walk when an academic is balancing the needs of two professional identities – the surveying and engineering professional development requirements must be balanced with those of the professional academic.

5.4 Throwing the Cheese into the Volcano

While we are yet to collect evidence from our colleagues on how their own authentic journeys are progressing, we can provide a non-exhaustive list of the authentic actions we have taken in our own journeys:

- We use things that we like to make classes interesting, including Lego, dinosaurs, games, superheroes and zombies. Turns out you can teach logic gates with dominoes, volumes with Lego and database design with a bag of mixed lollies.
- We have used Lego and dinosaurs to add a touch of fun to events, most recently orientation where two large inflatable dinosaurs welcomed students to the session.
- We gave a university-wide presentation on re-thinking orientation while wearing matching Lego pyjamas.
- We now have a whole library of themed shirts to choose from – no more pyjamas! People have begun to ask what shirts we will have for different events so they can participate. Is this what it is to be an influencer?!
- We do not blur our office backgrounds when doing recordings or holding online classes. The students can see our collections of dinosaurs, Pop Vinyls, Lego and minifigs and other trinkets we have collected in our professional lives. As well as the piles of mess! They make for good talking points when a new class starts. (In the event we do put on a background, there is a good chance that Lego is featuring…)
- Our technical lab spaces also have a variety of ‘decoration’ – the Survey Store at Springfield campus has a display of Lego minifigs that first year classes contribute to by making a minifig to represent themselves.

While we are by no means done on this journey, some of the key learnings for us as professionals, academics and individuals have been:

- You can be a friendly authority figure.
- Being a professional is best demonstrated by technical knowledge, collaboration and respect, not by wearing a shiny suit and a tie.
- Acknowledging mistakes and taking action to correct them is not only authentic but is modelling good professional behaviour for students.
- Supporting colleagues to be authentic can be a challenging journey, and some will take longer to figure out what their ‘professional’ authentic self looks like than others.

6 CONCLUDING REMARKS

In this paper, we have presented some of the weird and wonderful ways we tried to make surveying and engineering education not just more authentic, but also engaging without compromising curriculum. While the majority of the discussion has referred to anecdotal observations, it has hopefully provided a unique insight into some of the work and philosophy that goes into educating surveying and engineering students at UniSQ.

We urge anyone involved in the education of surveyors and engineers to reflect on their contribution to the learning journey. Do you have a clear understanding of what is trying to be achieved, and how it is to be achieved? Are these the things that you should be aiming for, or are they the things that you have always just done? Are the activities that students are being asked to undertake really a reflection of the learning outcomes, or have they been done out of habit and ease of process?

And most importantly, never be afraid to ask the hardest question there is in education: But why? Preferably while wearing a dinosaur T-shirt…

ACKNOWLEDGEMENTS

As mentioned earlier, it is worth noting that we are lucky to have a number of amazing colleagues who are not lactose intolerant volcano gods and genuinely engaged with our ideas and helped us bring them to fruition – you know who you are! We are really grateful to have you on this journey with us. We would also like to thank our families for putting up with the weekend and overnight absences while we worked crazy hours – Darren, P, Fletch, Tony, Hannah and Callum, you're all rockstars.

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The Surveyor Pirate of the Caribbean

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ABSTRACT

It appears that in the early days of the settlement of New Orleans, Louisiana, USA, a career change from the profession of land surveying and architecture meant venturing into the more lucrative, albeit less legal, undertaking of a privateer, which is actually a more polite word for pirate! Land surveyor and architect, Barthelemy Lafon, who had hailed from France, built up an impressive portfolio of land surveys combined with an equally extensive corpus of buildings attributed to his designs. Who knows what influenced this locally reputable pillar of the community to join with fellow Frenchmen, the notorious brothers Jean and Pierre Lafitte, the enigmatic pair who had a spurious agreement with the English and US overlords to sack Spanish vessels (and any others which ventured into their territorial waters?) and skirted with a death penalty to loot these hapless captains. It was indeed ironic that this duo of treacherous characters avoided execution by rendering courageous support to US General Andrew Jackson in conquering a much larger English force in the Battle of New Orleans in 1815, virtually being the last concerted effort by the homeland to suppress the rebellion of their northern American colonies on US ground. This paper presents an excellent sample of surveys and edifices attributed to Lafon, along with tales of some of his raids of piracy.

KEYWORDS: *Barthelemy Lafon, New Orleans surveyor, architect, pirate.*

1 INTRODUCTION

Spanish explorer Hernando de Soto discovered the body of the Mississippi River between 1541-42, but it was not until the Frenchman Robert Cavalier (Figure 1), Sieur de la Salle, erected a cross in 1682 at its mouth that the territory was formally claimed in the name of the French Sun King, Louis XIV, for whom Louisiana is named (State of Louisiana, 2023). In 1718, New Orleans was founded, being named after Phillipe Duc D'Orleans, younger son of King Louis XIII, with the oldest cathedral in the US, St. Louis Cathedral, being erected in that same year. It was destroyed in the 1788 fire to be rebuilt in 1794. Adjacent to this holy establishment was placed the Cabildo, the Governor's residence, in which the later mentioned treaty was signed in 1803. In 1762, the succeeding King Louis XV ceded all of Louisiana west of the Mississippi to his cousin, Charles III of Spain, with the Treaty of Paris formally confirming this transfer in 1763 (Chamberlain and Farber, 2014).

In the final years of Spanish administration from the great fire of 1788 to 1803, the enactment of Spanish building codes resulted in the erection of Spanish colonial style architecture, particularly in the ironically named French Quarter, such exteriors requiring stucco and tiled roofs including customary patios and long iron balconies as were found in the haciendas of southern Spain. Even after the formal transferral of the Louisiana territories to the US in 1803, the elite Creole planter-merchant class dominated commerce and the social life of the burgeoning community for a substantial period from that event (Chamberlain and Farber, 2014).

Figure 1: French explorer Robert Cavalier who claimed the Mississippi River in the name of Sun King Louis XIV to later give the name of Louisiana to the whole territory.

When the 3rd US President, Thomas Jefferson (also District Surveyor for Albemarle County), signed the Louisiana Purchase Treaty on 30 April 1803, the continental land mass of the United States of America was to be doubled, adding to its original 13 states all of the recently acquired French territory west of the Mississippi River (Figure 2). This amazing real estate transfer cost the US Treasury a mere US$15 million, which, even in modern terms, was more like a 'fire sale' than a market value transaction. 530 million acres (828,000 square miles) of land was obtained for 3 cents an acre in what is the largest land acquisition in US history (State of Louisiana, 2023). The final hand-over of the lands from Napoleon Bonaparte took place on 20 December later that year.

Figure 2: Coloured green is the area of land purchased by the US government from France by the Louisiana Purchase Treaty, which was signed on 30 April 1803 for US$15 million – US President Thomas Jefferson on the left and Napoleon Bonaparte on the right (Rawat, 2018).

Immediately, at the mouth of the mighty Mississippi River, and to the east, lay the new area later to be the State of Louisiana. Much of the occupied land had Spanish tenants, who had inhabited the farms during the Spanish occupation, which preceded the French ownership by about 40 years. In what could be described as the greatest land gazumping in world history, France's fanatical self-proclaimed 'Emperor' hoodwinked the cash-strapped Spanish authorities by calling in a debt owed, so that he could then swiftly pass on the extensive territories west of the Mississippi to finance his failing battle against the English in arenas of conflict on the other side of the planet.

It was a commensurate land swindle and double deal, but the new states of America were unperturbed as they quickly absorbed the ownership of these neighbouring lands into their vastly expanded dominion. Although held under the Spanish flag, New Orleans had a culture identifying with the many French settlers who had migrated from their homeland with their descendants emerging as a white Creole merchant/planter class mainly conversing in a dialect of French origin.

2 LAFON’S EARLY YEARS IN NORTH AMERICA

Born in 1769 (the same year as Napoleon Bonaparte!) in the old town of Villepinte in the Departement de l’Aude, Province of Languedoc, in France, along the Canal-de-Midi which connects the Mediterranean to the Atlantic (Cultural Landscape Foundation, 2023), Barthelemy Lafon (Figure 3) spent his first 20 years under the Ancien Regime with Bourbon kings reigning over a nation where the privileged families enjoyed an elite lifestyle. However, with his coming of age in 1789 came the Storming of the Bastille on 14 July 1789, which started the French Revolution. This uprising meant upheaval and often death to the Bourgeoisie, so he fled the threat of the guillotine never to return to his birthland.

Figure 3: Portrait of Barthelemy Lafon by Jessica Strahan (2018).

Possibly passing through the spheres of French influence in St. Domingue or Haiti, he may have travelled through Cuba, but whichever route he took he made his way to the ‘French’ Louisiana Territory sometime around 1789-90. The sparsely populated lands are said to have reminded him of his rustic origins in rural France, and despite Spanish dominion over the territory since 1763, French was still the prevailing tongue together with compulsory Catholicism for all residents. Thus, it must have seemed like divine providence when Napoleon cut the deal to take the lands from Spain, then just as expediently disposed of all of the territory to the young US establishment in 1803 (see Figure A1 in Appendix A).

Shortly after his arrival in his new home, Lafon established an iron foundry in the lower area of Canal Street and a “brick plantation” in 1801 (see Figure A2 in Appendix A). The need for his architectural services must have been in strong demand, particularly in the sphere of public works repair projects. He prepared plans for the restoration of the city gaol in 1794 due to its damage from the fire of 1788. Four years later, he was called as an expert to assess the repair works on the Presbytere and Cabildo, which was the residence of the Governor. During the period from 1797 to 1799, he brought about improvements to the covered gutters of the city, while in 1802 he reconstructed the riverfront levees. For these intervening 13 years, Lafon was in the right place at the wrong time because a terrible fire had destroyed much of New Orleans in 1788, which could only be considered a wrong time!

However, for the newly arrived French architect/surveyor it was the perfect time to join an economy craving new designs for lost residences or restoration plans for partly damaged structures worth saving. His expertise in hydraulic engineering was also keenly employed to build and repair those levees damaged by flooding, which was a constant threat and still is to this day. He was such a busy man that he engaged another French-born surveyor, Jean Baptiste Pene, to assist him. He also employed scribes to prepare many of his survey "warrants". His survey duties comprised verifying land grants and land purchases, along with establishing precise borderlines between extensive rural French long lots (which meant plantation properties along the Mississippi or the numerous nearby bayous) or measuring boundary lines of the narrow urban lots in New Orleans city. Every inch was important with his services called upon to also evaluate the land for its potential usage (Edwards and Fandrich, 2018, p.1-2).

His first private commission is probably in 1794 for a dwelling for Mademoiselle Jeanne Macarty at the intersection of Conti and Decatur Streets in a typical colonial New Orleans design with a brick ground level containing stores, then a half-timber colombage second floor with plastered formal rooms and wood-panelled chimney breasts. Some other significant townhouses of the late Spanish colonial era accredited to Lafon by stylistic comparison are such works as the Barthelemy Bosque House at number 616 Chartres Street (c. 1795), a later 1790s residence for Vincent Rilleaux at 343 Royal Street along with another 3-storey premise at number 634 in the same street (Figure 4), and a c. 1795 building called Joseph Reynes House on a corner allotment at Chartres and Toulouse Streets. In 1797, he was engaged to build a larger similar home for the merchant Jean Baptiste Riviere at the corner of Bienville and Decatur Streets, made taller by adding an entresol as well as including more elegant features like carved mantles, a rose window and pediment with a sculpture. He is also credited with the 1799 De La Torre House, standing at 707 Dumaine Street, New Orleans (see Figure 4) (Masson, 2012).

Figure 4: (Left) Lafon designed 1795 house at 634 Royal Street, and (right) the 1799 De La Torre House at 707 Dumaine Street, New Orleans.

3 IN THE NEW ORLEANS SURVEYOR-GENERAL'S DEPARTMENT

As Masson (2012) put it, "Barthelemy Lafon enjoyed a long and diverse career in Louisiana as an architect, builder, engineer, surveyor, cartographer, town planner, land speculator, publisher and pirate." Such a quotation demonstrates the wide spectrum of activities with which Lafon was associated, but it is quite an anomalous finale which includes "and pirate"!

During his formative years in New Orleans, he carried out most reputable projects in town planning, building and mapping together with his many exploits in surveying, which create an image of a man fighting between two worlds of existence. In a Jekyll and Hyde parody, he performed the professional needs of his community to the fullest, but he was clearly torn away into a life of swashbuckling adventure in the dubious underworld of privateering, otherwise recognised as legalised piracy. As his life story unfolds, this darker side of his character will arise towards its finale. Nevertheless, his amazing professional performance belies his disreputable demise.

One of Lafon's early commissions included an 1803 survey of Galveston (now Galvez, LA, near Baton Rouge) for the Spanish along with maps and surveys of New Orleans. Having gained a solid reputation for his private surveying activities, and despite two bitter disputes relating to two of his architectural projects which may have sullied his name in this field, he was seconded to the Surveyor-General of Orleans County between 1804-09, duly appointed by Isaac T. Briggs, Surveyor-General of the lands South of Tennessee (Edwards and Fandrich, 2018, p.8). During his service with this department, he still carried on with designing buildings and creating green subdivisions in some of the new suburbs.

Lafon's work as a surveyor was said to be "extraordinary", both working for private clients and the administration as well as designing developments adopting the principles of European Garden City designs. His initially preferred style of map preparation was based on his Spanish Surveyor-General Carlos Trudeau's style (Figure 5), but he later began introducing his own features to the works, such as dual language plans (Figures 6-9). He completed work on one of the earliest and most accurate maps of Louisiana in 1805 called "*Carte Generale du Territoire d'Orleans Comorenant Aussi la Floride Occidentale et une Portion du Territoire du Mississippi*" (Figure 8). Some of his other plans include Mouths of the Mississippi (1810 & 1813 – see Appendix B), English Turn (1814), the Balise (1814), Port St. Jean (1814) and Fort Bower (undated) on Mobile Point. Another map of New Orleans in 1816 illustrated the rural areas with new suburbs created around the nearby plantations (see Figure B3 in Appendix B).

His elaborate designs were shown on plans for the Lower Garden District, which crossed five plantations (Soule, La Course, Annunciation, Nuns and Paris) to include all land up to Felicity Street. Being a connoisseur of the classics, he gave the streets the names of the nine muses in Greek mythology: Calliope, Clio, Erato, Thalia, Melpomene, Terpsichore, Euterpe, Polymnia and Urania. The sophistication of his plans bore tree-lined canals, fountains, churches, markets, a grand classical school, and even a coliseum. Most of these decorative inclusions never materialised, but his grid pattern for the street layout along with the parks and, of course, the street naming survived.

Figure 5: (Left) New Orleans Spanish Surveyor-General Carlos Trudeau (aka Charles Laveau), and (right) the 1802 map of New Orleans by Carlos Trudeau.

Figure 6: 1802 Lafon map of Lower Louisiana and Western Florida.

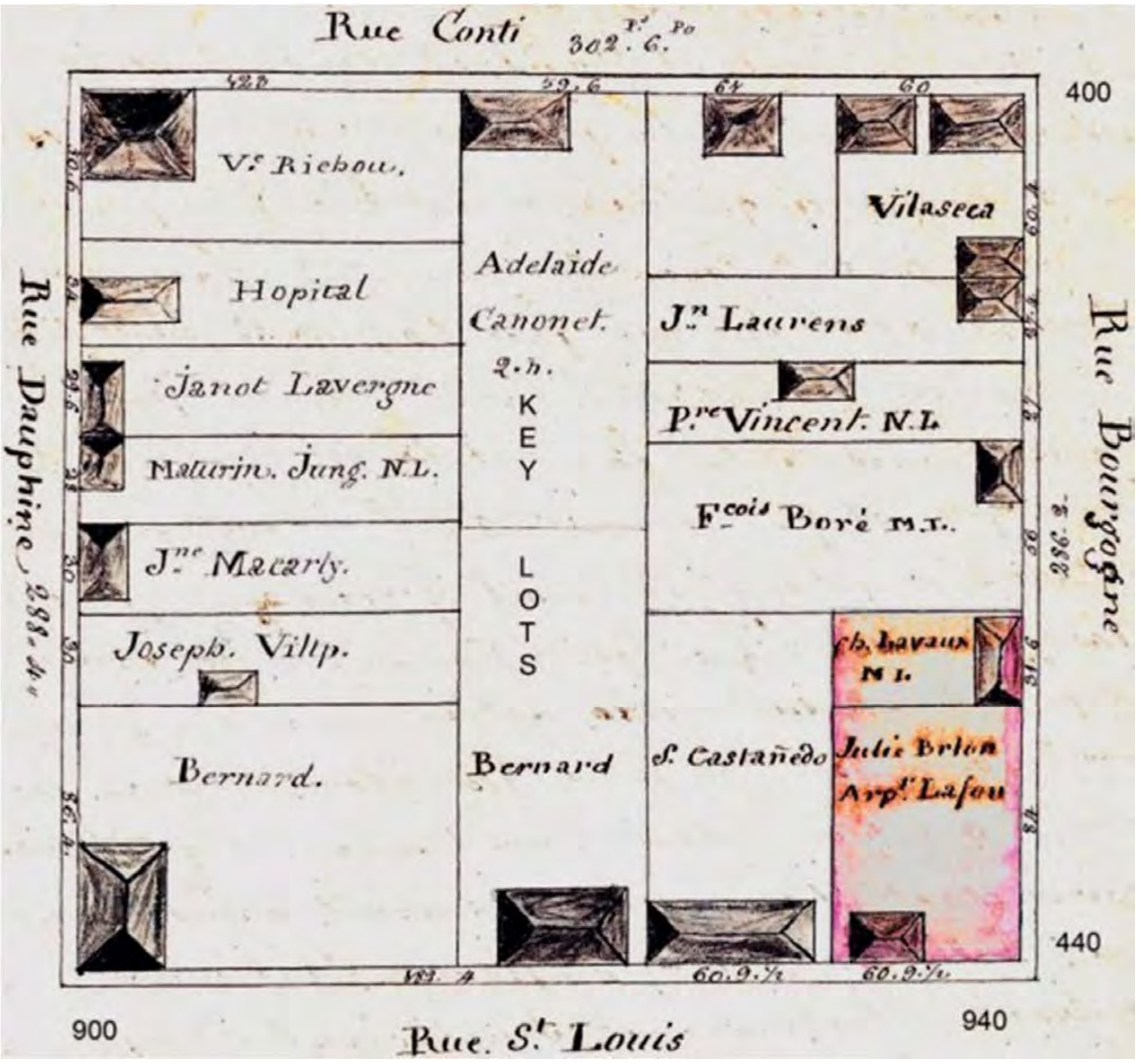

Figure 7: French Quarter Square 91, surveyed in September 1804 (Lafon Survey Book No. 3, p.46). The allotment shaded pink is the property acquired by Lafon at the time of this survey, it being where the house in which he died was located (Edwards and Fandrich, 2018, p.28).

In 1806 and 1807, he created influential subdivision plans of the Delord-Sarpy Plantation, enlarging Fauborg St. Mary to resurrect Fauborg Annunciation further up along the river. In keeping with European style trends and in departure from the grid street design, he featured circular designs with radiating streets and diagonal boulevards to provide vistas together with space for major public buildings. Sections of the Bywater and Bayou St. John neighbourhoods were designed by Lafon. Amongst his professional service consultancy were mapmaking, planning the town of Donaldson in 1806 as well as surveying and advising for upgrading the fortifications of New Orleans during the War of 1812 and the Battle of New Orleans in 1815, which saw the end of English aggression to subvert the young American colonies (Peoplepill, 2023). Lafon had been recruited as an engineer for the US Army, being a Captain in the 2nd Regiment of the US Militia of the Territory of Orleans, preparing many maps for Governor Claiborne during the war.

Lafon was a man of diverse talents. In 1807, he published the first almanac of New Orleans, "*Calendrier de Commerce de la Nouvelle Orleans Pour l'Annee 1807*", as well as "*Annuaire Louisianais Pour l'Annee 1809*" (Edwards and Fandrich, 2018, p.12). Lafon's contribution to the redevelopment of New Orleans and the mapping of Louisiana was indeed "extraordinary", but his participation in the two wars waged against the British on his home territory in 1812 and 1815 would seem to have been overlooked when US President Andrew Jackson evaluated his courageous and invaluable involvement in defeating a vastly superior (in number, at least?) British war machine.

Figure 8: One of the earliest and most accurate maps of Louisiana 1805 by Lafon – *Carte Generale du Territoire d'Orleans Comorenant Aussi la Floride Occidentale et une Portion du Territoire du Mississippi.*

Figure 9: Map of the land around Fort Petites Coquilles by Lafon, c. 1810 (Masson, 2012).

4 LAFON DURING THE BRITISH WARS AND AS A PIRATE

Promoted to Major in the US Militia Engineers, Lafon was able to improve the defence capabilities at various forts around the territory, inclusive of Petite Coquilles in 1813 (Figure 10 and Figure B5 in Appendix B). Officially becoming the State of Louisiana in 1812, the US became embroiled in the War of 1812 against the militant British Navy who continually attacked American merchant ships, forcibly pressing their crews into their own naval service.

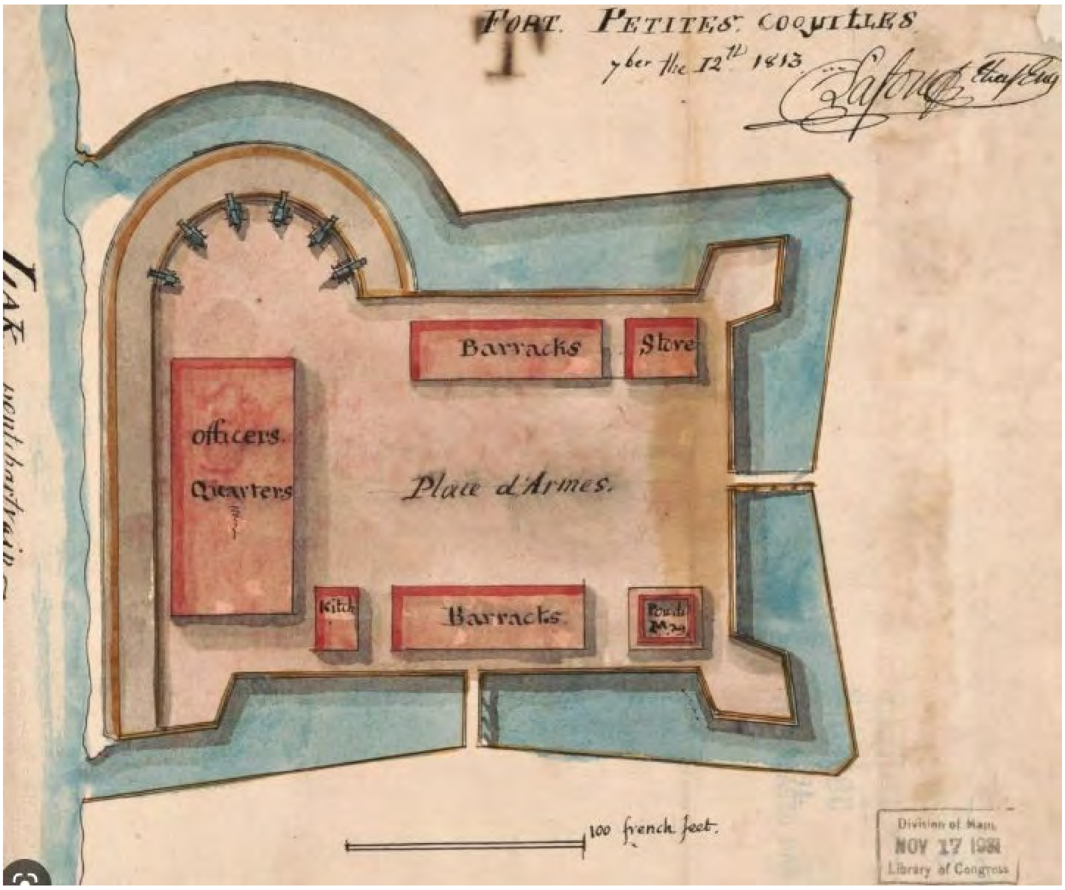

Figure 10: Lafon 1813 plan of fortifications at Petite Coquilles.

For years, Lafon had a close affiliation with the Laffite brothers, Jean and Pierre Laffite, who called themselves Baratarian privateers, operating from the island Barataria in the Gulf of Mexico (Figure 11). It is quite likely that Lafon had early acquaintances with the pirating brothers, possibly meeting in Bordeaux, France, before migrating across the Atlantic to America, or even cooperating during the Haitian rebellion when many French refugees from that country escaped to the eastern US. Whenever the first contact was made, there is no doubt that Lafon had been a close ally of the brothers for a number of years during which time he plied the seas in his own privateering ship *La Carmelita* upon which it is known that a number of liaisons between the three men ensued. In August 1813, Lafon had the use of a vessel named *La Misere*, which hijacked a prize called the *Cometa*. In 1814, Lafon participated in an operation leading to the capture of two Spanish vessels, which was followed by Lafon and others facing indictments for piracy (Guerin, 2010).

After the British had rid themselves of conflict against France, then forcing Napoleon into exile, they deployed their efforts into razing Washington DC, in August 1814. The principal target was then the capture of New Orleans to gain control of the Mississippi River waterway. Facing a British force of around 9,000 troops, US President/General Andrew Jackson struck a deal with the leaders of the Baratarian pirate brigade of some 1,200 individuals, to pardon the recently captured Jean and Pierre Lafitte plus Lafon along with returning their vessels. Jackson's total force of some 5,200 men were able to incur substantial damage on their opponents, with the British losing three Major Generals (including Packenham) along with 2,033 soldiers, while only suffering less than 20 casualties (Edwards et al., 2019, p.61).

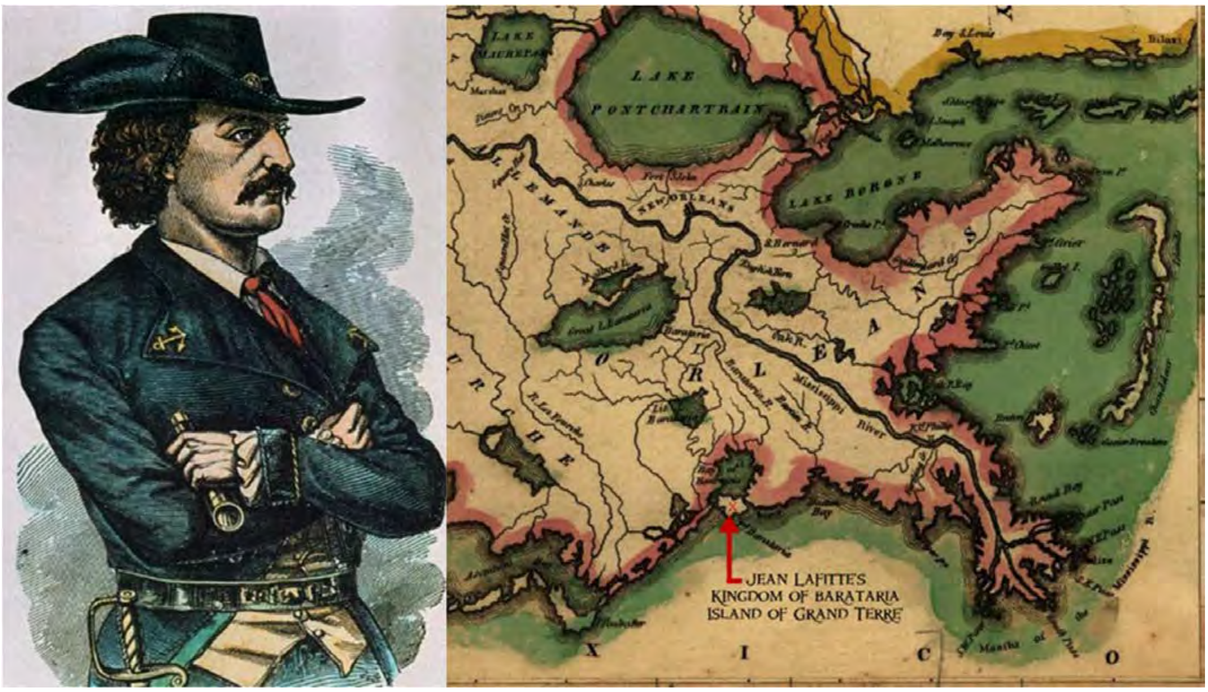

Figure 11: (Left) New Orleans privateer Jean Lafitte, and (right) locality map of the pirate island Barataria in the Gulf of Mexico which was the stronghold of the looting enterprise.

When the smoke cleared from this war-ending decisive rout, the back-stabbing US President Jackson reneged on his pledge and held onto the privateer ships and goods that had been confiscated on the earlier raid on the pirate stronghold of Grand Terre. Although released from prison, the two brothers and Lafon remained under close suspicion, and, while still under US assault, they eventually fled New Orleans completely (Edwards et al., 2019, p.62). The Lafitte brothers re-established themselves on the island of Galveston in Texas, for good, with Lafon joining them during their first two years of resettlement.

Before leaving the pirate stronghold in this new locality, Lafon still acted as a surveyor for the Spanish government, measuring and drafting the map "*Entrada de la Bahia de Galveston*". He also surveyed other regions in the southwest, at the same time acting as an official spy for the Spanish. Duplicity seemed to be the norm for these buccaneers of the high seas, as it is also firmly believed that Lafon and the Lafitte brothers acted as double agents, supplying espionage data to the US administration. The Mexican government in control of Texas at the time reacted very forcibly when the colony of Mexican patriots resident on the island conspired with the Lafitte brothers and Lafon to raid some Spanish ships flying the Mexican flag. After Lafon couriered a shipment of munitions to Galveston, his ship was seized on the high seas by agents of the Galveston "government" (Edwards et al., 2019, p.63).

5 BACK TO NEW ORLEANS IN 1818 AND FINAL DAYS

Having endured enough in Galveston, Lafon was back in New Orleans in 1818. His professional name in surveying and architecture had been irreparably soiled through his association with the notorious pirate brothers, his own privateering and the indictment for piracy handed down by the New Orleans District Attorney, John Dick, in February 1815. After this, he spent a short stint in gaol before he was finally acquitted (Edwards et al., 2019, p.62).

Lafon's choice of returning to New Orleans was more closely related to his desire to be back with his lifelong love, Modeste Foucher, who was a free woman of colour, and their four children (Edwards and Fandrich, 2018, p.11). With minimal success in his attempt to reinstate his professional career, Lafon attempted to sell all his possessions with an ultimate desire to return to his homeland where his father and brother still lived. Starved of work and destitute from Government Internal Revenue Department fines and costs in defence of the lawsuits demanding him to repay unpaid duties on the booty plundered from vessels which were the victims of his daring privateering, Lafon found himself in a whole world of despair. His halcyon days of brilliant chart making, skilled surveying and stylish architectural design had deserted him. His glorious dreams of sailing back to France with his coloured partner and children, so that they could marry and be free of the discrimination imposed upon them in the class-conscious New Orleans society, could not be further away from being realised.

Just when it could not go downhill any further, a yellow fever epidemic claimed him on 29 September 1820 at the modest age of 51 years. He died in his home at No. 934-36 St. Louis Street in square 91, originally purchased in 1804 from the estate of the wealthy woman of colour, Julie "Betsy" Brion (Figure 12, who was the mother of Modeste with Joseph Foucher) (Edwards and Fandrich, 2018, p.10). Lafon was buried in St. Louis Cemetery No. 1 (Figure 13 and Appendix C).

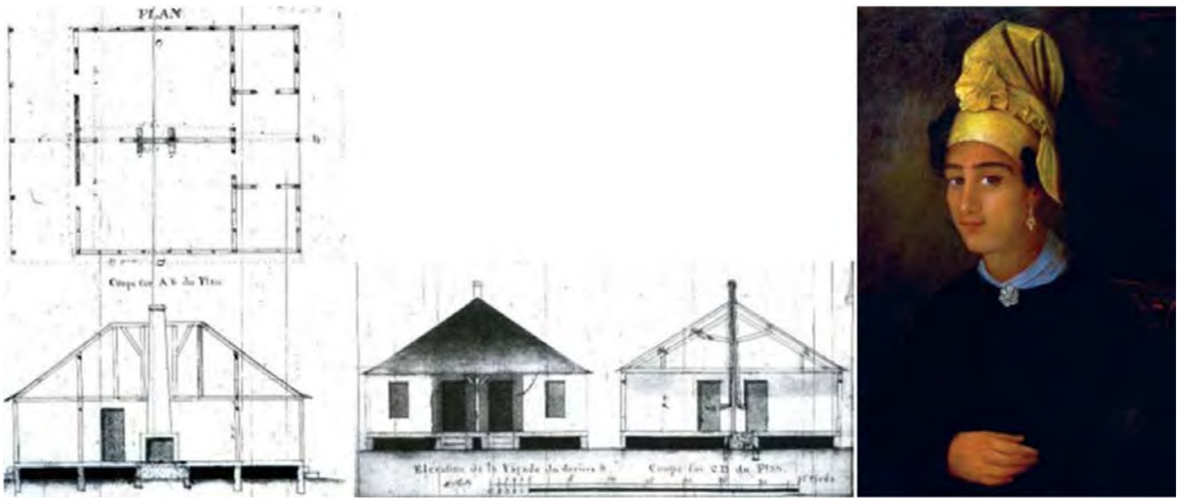

Figure 12: (Left) Lafon architectural plans for one of his homes at Chef Menteur built in 1806, and (right) 1837 portrait of Julie "Betsy" Brion, from whose estate he bought the land upon which he erected the house in which he passed away in 1820.

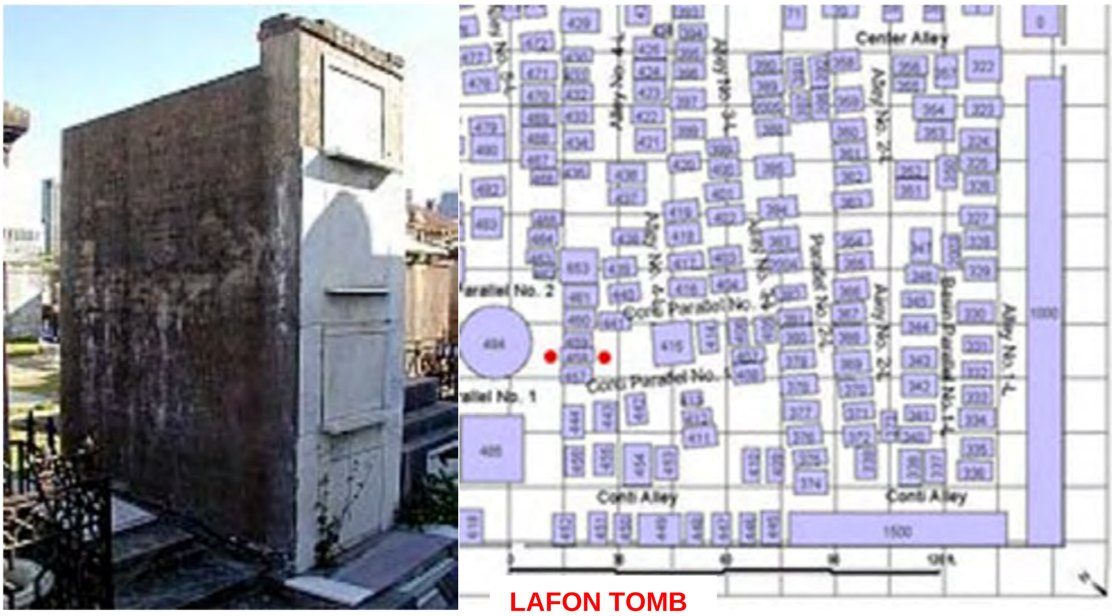

Figure 13: Barthelemy Lafon's vault in St. Louis Cemetery No.1 and its locality plan.

6 CONCLUDING REMARKS

The ultimate demise of Barthelemy Lafon from a man of distinction to a penniless pirate are a sorry tale of riches to rags, finally played out to the humiliation of his family members, making a fruitless most lengthy journey from France in pursuit of what was believed to be a vast estate of land holdings and other investments amounting to an Emperor's ransom. His father Pierre Lafon Snr. was in his mid-80s on the long trip across the Atlantic, but most tragically died not long after his arrival in 1822, stricken down by the same yellow fever, which had claimed his son. Next to take the prolonged trip was Lafon's older brother of 7 years, Pierre Lafon Jnr., accompanied by his 54-year-old wife Jeanne Victoire. After a mere few days, Jeanne had died of the same deadly disease, with her husband contracting the fatal fever to pass away in the following month on 19 October 1822 at the age of 60. The last one standing from the immediate family was the daughter of Pierre Jnr. and Jeanne, the spirited Jeanne Philippe Lafon, who was Lafon's niece. With the obligatory post-humous inventory of Lafon's estate the Court of Probates listing a large portfolio of real estate, over 50 field slaves and domestic servants, and a library of over 500 books, the extended journey over the water appeared to offer a mighty inheritance for the last member to risk death in the epidemic to claim her entitlement! Pursuing the battle for Lafon's estate to the Louisiana Supreme Court, she eventually won, only to hear the court pronounce that the entirety of Barthelemy Lafon's estate "was wholly insolvent and unable to pay the legacies and debts" (Edwards et al., 2019, p.66).

Thus, the fall of Barthelemy Lafon from reputable professional at the top echelon of the community, to which he made so many invaluable contributions both physically and financially, can only be the side effects of his strong allegiance to the notorious plundering Lafitte brothers, creating a rather unfavourable picture of his activities in the dubious exploits of privateering, the polite name for condoned piracy. Whatever image of disrepute may have been associated with Lafon in his later years, there can be no doubt that his excellence in surveying, mapping, engineering, architecture and town planning have survived him, as the brilliance of his European garden design suburbs, his many stylish and attractive buildings, practical restoration of roads and flood levees and superb maps of New Orleans and Louisiana stand in testimony to a complex character of early American history. He was a hero of the Wars of 1812 and 1815, which saved his territory from British domination, and his practical solutions with a sharp mind can only be attributed to his professional training and experience as a land surveyor.

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APPENDIX A: PLANS OF NEW ORLEANS

Figure A1: 1803 Vinache Plan De La Nouvelle Orleans in celebration of France's short reoccupation of the city before the Louisiana Purchase Treaty was completed.

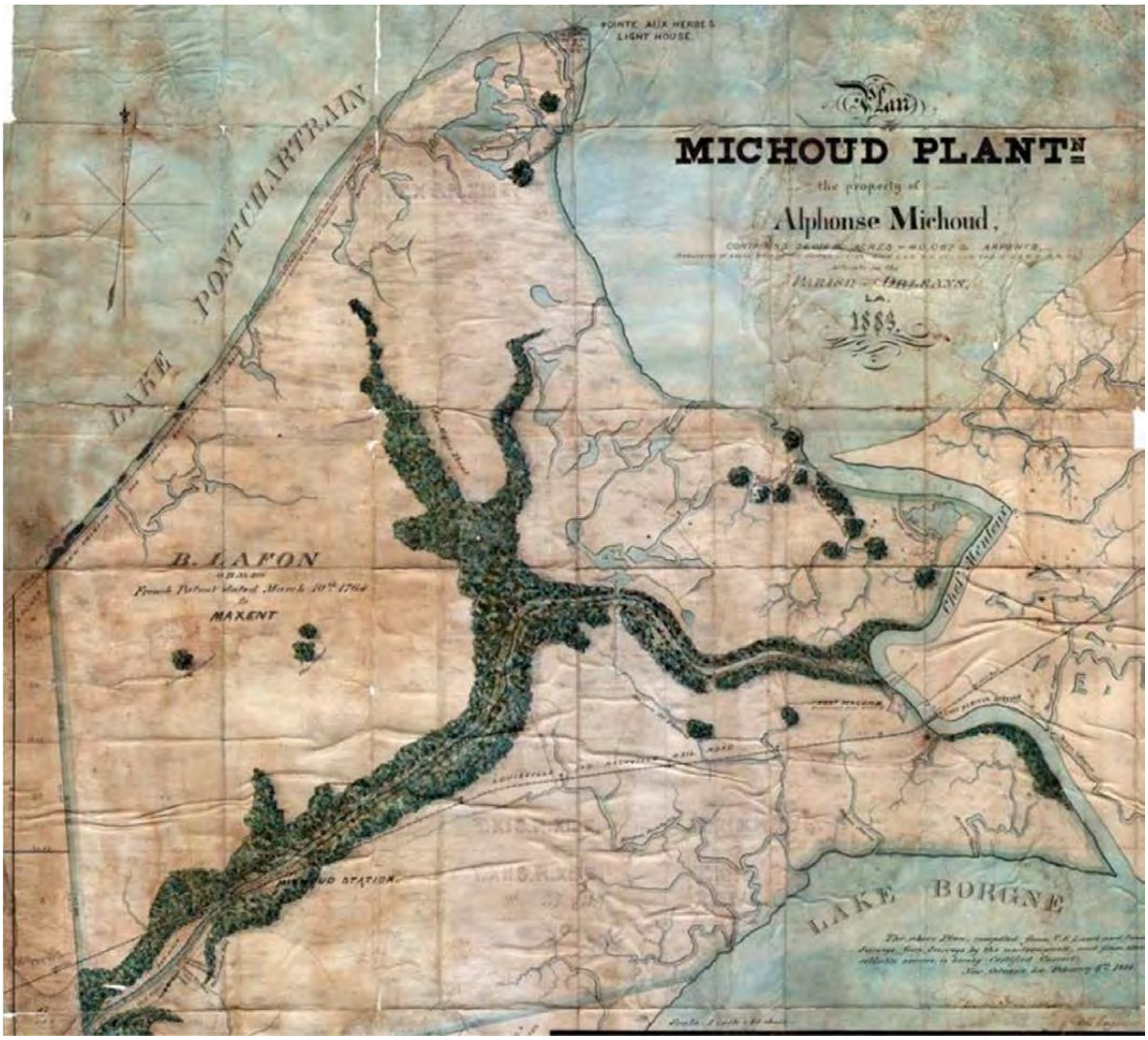

Figure A2: Plan of the easternmost section of New Orleans by George H. Grandjean titled “Michoud Plantation”, being the property of Alphonse Michoud comprising 36,056 acres. “B. Lafon” can be seen printed on the left portion of the plan. Barthelemy Lafon had gained ownership of this tract of land in 1801, which he used for what was said to be a “brick plantation”. He lost this holding to creditors in 1812.

APPENDIX B: PLANS BY BARTHELEMY LAFON & LATER PERSPECTIVE VIEW

Figure B1: 1810 Lafon plan of the mouths of the Mississippi River.

Figure B2: No. 4 plan of the mouth of the Mississippi, June 1813.

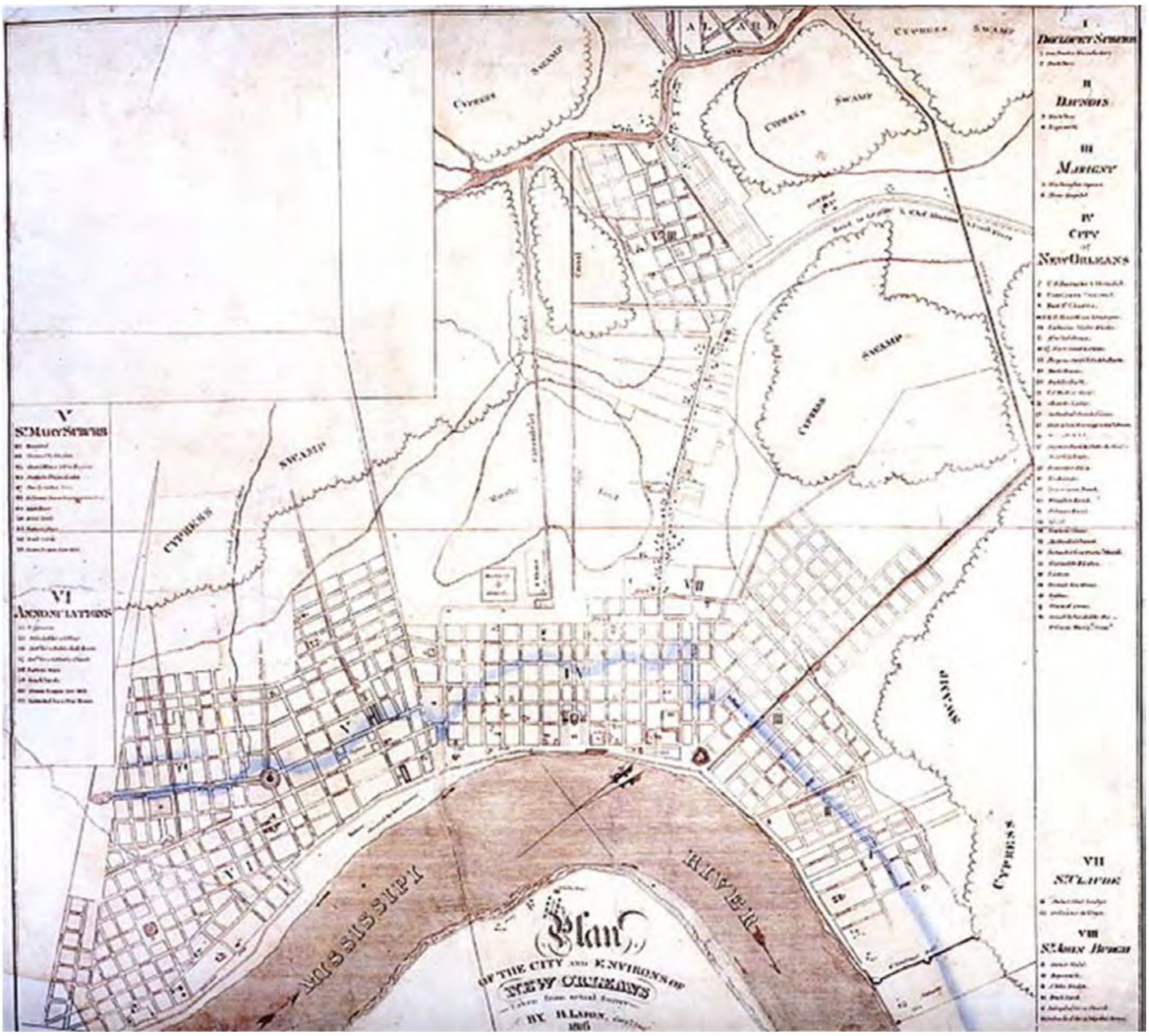

Figure B3: 1816 Lafon plan of the city and environs of New Orleans.

Figure B4: Perspective view of New Orleans and the Mississippi River from 1885.

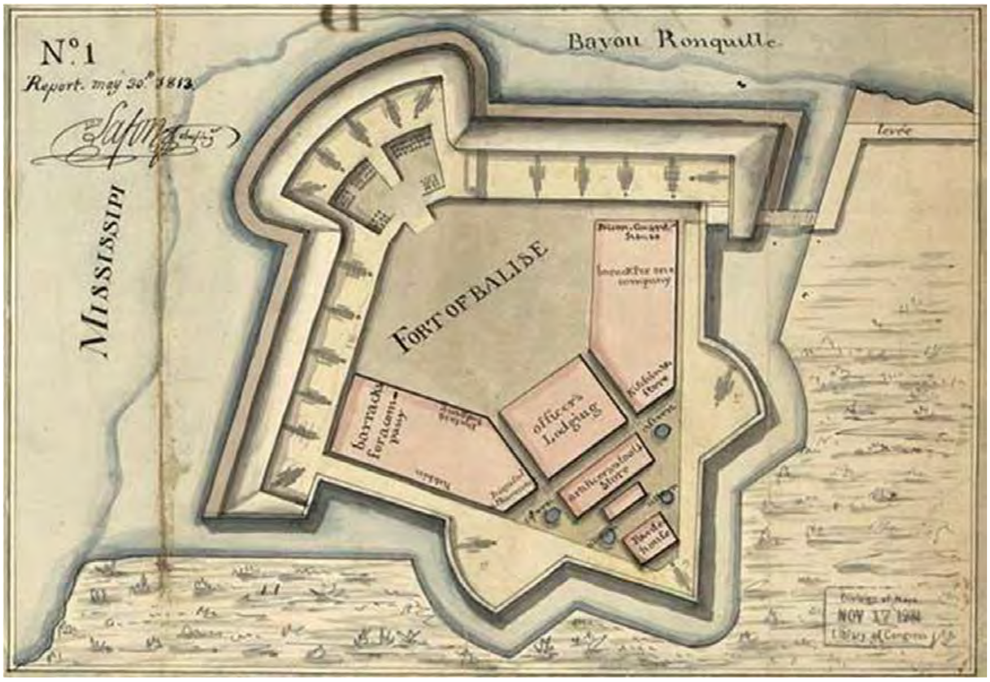

Figure B5: Lafon plan of Fort Balise, 30 May 1813.

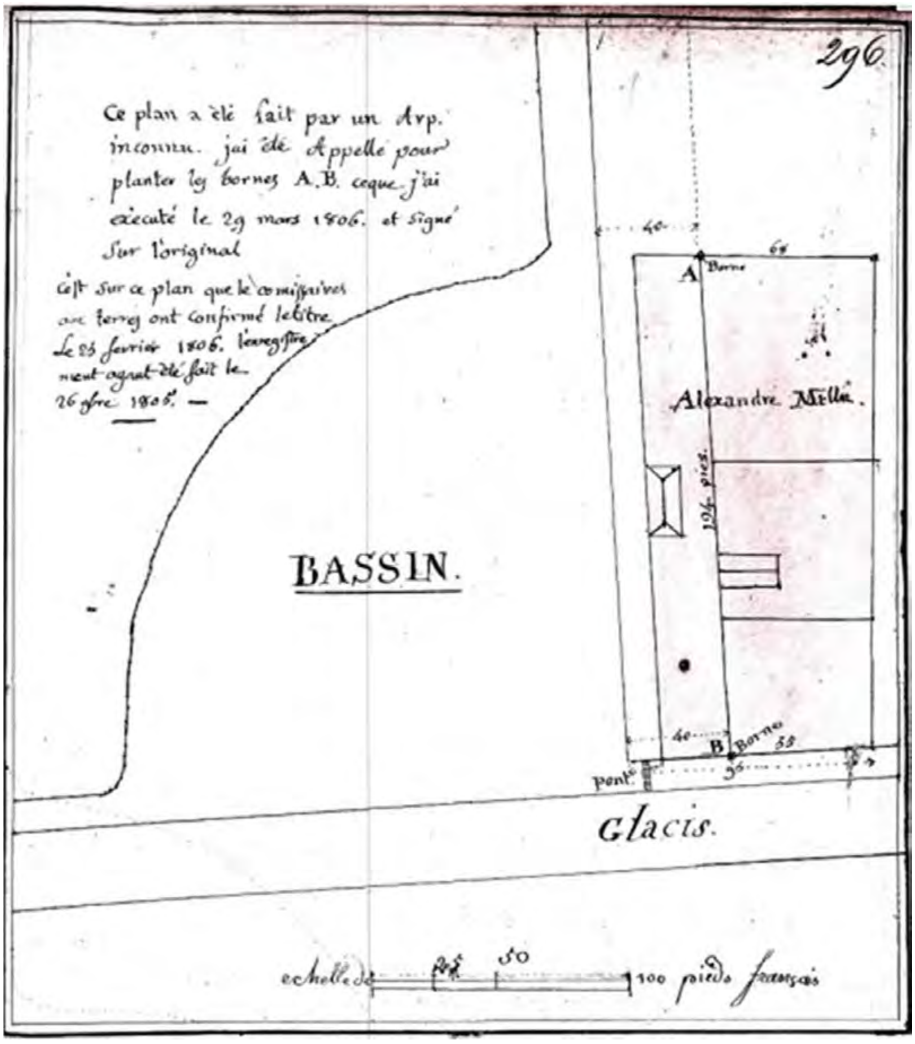

Figure B6: Lafon re-survey of the Carondolet Canal turning basin and land of A. Milne, 29 March 1806.

APPENDIX C: NEW ORLEANS MAP WITH STREET NAMES AND SQUARE SECTION NUMBERS

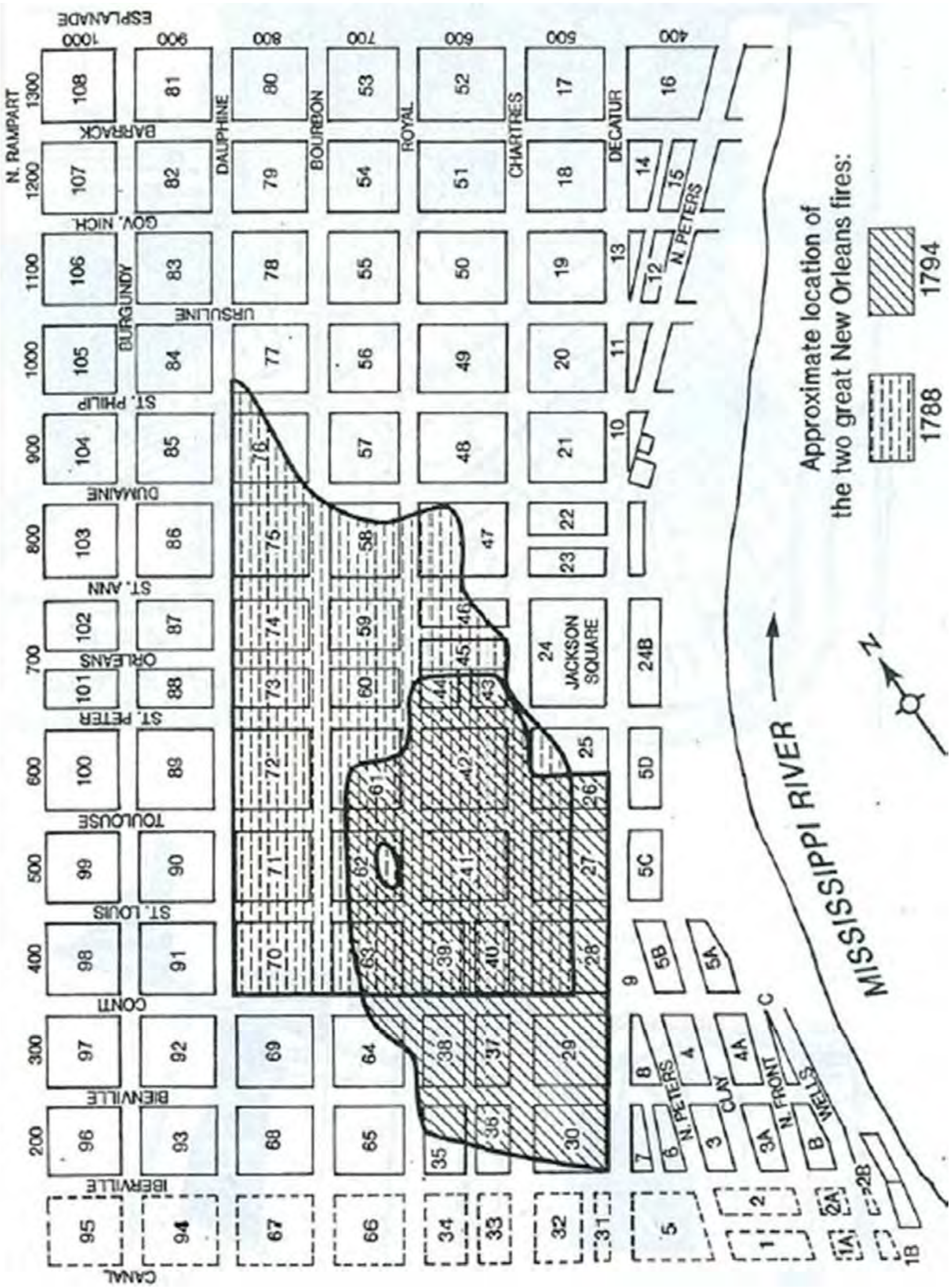

Figure C1: The street pattern of New Orleans City, showing street names and section numbers as allocated to the locality descriptions for identification of property, with square 91 being where the house in which Lafon died in 1820 is situated.

Alienation of an Alien Nation

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ABSTRACT

When the First Fleet arrived at Sydney Cove in 1788 to establish a penal colony in a completely strange and unknown land, the priority was to cultivate farmland to guarantee a regular food supply. The Eastern Farms (now Ryde) was one such area. Under the misguided belief that Australia was ungoverned, the new settlers claimed the land in the name of their own Crown (King George III of England). With this claimed ownership came the power to grant parcels of land from the Crown Estate, i.e. the alienation of Crown land. In the role of Governor, Arthur Phillip commenced the granting of land in 1790. The First Crown Grants in Ryde continued from 1790 until 1809. No further granting of land in Ryde occurred until 1882 and 1887 when the Crown subdivided and released part of the Field of Mars Common. This paper discusses and aims to answer the following questions: Just what was granted? How was the land in the grant described? Where was the grant situated? The first official grants of land on the mainland were issued to marines Archer, Colthread and six others in January 1792. Grants of Crown land were free up until 1831 and the final Crown land grant in New South Wales was in 1981 to the trustees of St Vincent's Hospital, Darlinghurst, in Sydney.

KEYWORDS: *First grants, first marking, first maps, cadastral surveying, City of Ryde*.

1 INTRODUCTION

In keeping with the theme of this conference, Captain Cook (although he was not acting for himself) was probably our first pirate to plunder down under, claiming and naming Terra Australis as New South Wales in 1770 during a ceremony at Kurnell on Botany Bay. Arthur Phillip arrived in 1788 with a motley crew carrying orders to establish a penal colony. For the subsequent settlement to survive, a degree of self-sufficiency was required, so arable land was sought for agriculture. Governor Phillip was empowered by King George III (Figure 1) to issue free grants of Crown land in New South Wales in order to facilitate this agriculture.

These free grants of Crown land, to willing first settlers, amount to the first alienation of the Crown Estate, or do they? Alienation, as a term, means separation, severing of ties or estrangement (especially where attachment formerly existed). Where some Crown land was delineated, marked and set aside for a specific purpose or use for the colony, was this alienation? Does the creation of a surveyed or defined parcel of land constitute an alienation? One can think of Government House, the first farm at what is now the Sydney Botanical Gardens, the site of the Government Stores or Fort Denison.

Figure 1: Official painting of King George III.

At law, alienation is more specifically the transfer of property rights (ownership). There are four property rights when it comes to ownership:

1) Right of possession.
2) Right of control.
3) Right of exclusion.
4) Right of disposition.

Does the transfer of only some of these rights still constitute an alienation? Even if the ownership remains with one landholder? Consider a subdivision of, say, three new lots, each defined by survey in a plan. Three titles are created. One lot is sold off, two are retained. Have any of the two retained lots been alienated?

If a land parcel is granted by the Crown to a freeholder (alienation) and later that parcel is returned to the Crown's ownership, does that land become unalienated again within the Crown's unalienated estate? Does the parcel retain its dimensioned identity within the Crown's estate? If the parcel remains an entity with an identity, can it be released again in the same shape? Is squatting, which is the illegal taking (or pirating) of land, an alienation? Is adverse possession an example of alienation? This paper discusses some of these questions with the objective to better understand just what alienation is. A further topic, which is to be explored in a future paper, is the granting of land by Governor Macquarie in 1819 to two Aboriginal leaders in an act of reconciliation. Were these grants of land, back to the original custodians, an alienation? Are alienation of land and alienation of title two separate issues?

2 FIRST LAND GRANTS IN THE COLONY

The first Crown land grants in the new colony of New South Wales were signed off by Governor Arthur Phillip in 1792. The author's understanding is that the official seal for government documents did not arrive with the First Fleet, so had to be shipped in at a later date, by 1792.

The first grants bearing Governor Phillip's signature were actually 14 land grants on Norfolk Island (totalling 649 acres), together with 8 land grants on the mainland (totalling 690 acres). These were all dated 3 January 1792.

The first land grants on the mainland were given to a group of eight former marines, who decided to remain in the colony, after their term of office had expired, at Ryde and Ermington (in an area which came to be known as the Field of Mars) along the northern shore of the Parramatta River:

- John Colthread – 80 acres.
- Isaac Archer – 80 acres.
- John Carver – 80 acres.
- Thomas Cottrell – 80 acres.
- James Manning – 80 acres.
- Thomas Swinnerton – 80 acres.
- Alexander McDonald – 130 acres (either additional military recognition or family).
- Thomas Tynan – 80 acres.

Each of these grantees was given 80 acres (30 acres per man as decreed, plus 50 additional acres for being a military man). As was the manner of the day, the parcels adjoined, had parallel side boundaries and a rear boundary which was square. John Colthread's 80-acre grant was the easternmost, so it abutted unalienated Crown land. Within 2 years, John Colthread had married and become the father of a child, so he claimed a further land entitlement of 20 acres for his wife plus 10 acres for his child. In 1794, John Colthread was granted 30 acres at a location called Dinner Point, beyond a bay and over 500 m further to the east from his original grant (Figure 2).

Figure 2: John Colthread's 80-acre grant in relation to Dinner Point.

This 30-acre grant at Dinner Point was not taken up by John Colthread and subsequently re-granted as part of a 160-acre parcel to William Kent in 1799. However, there remained 220 acres of unalienated Crown land between Colthread and Kent. All this Crown land was granted to William Balmain (Figure 3) in 1799, with the parcel description stating that the grant abutted John Colthread's land on the west.

Figure 3: Portrait of landowner William Balmain.

However, this abutting boundary now displayed a significant bend towards the east when compared to the other boundaries of the original eight grants. The obvious answer is that John Colthread took up his extra 30 acres from the unalienated Crown land abutting him on the east, and not at Dinner Point, further away. As an existing landowner in the district and a prominent figure in the colony, it is unlikely and improbable that William Balmain would be unaware of the location of the eastern side boundary of John Colthread’s grant to which his subsequent 220-acre grant abutted.

On 22 February 1792, 7 weeks after these first grants in the Field of Mars, a further 52 grants were authorised, including one to James Ruse (Figure 4), at Parramatta. On a semi-official list of the land grants given by Governor Phillip, James Ruse is the first name mentioned, which probably explains why we were always taught in school that James Ruse held the first grant of land in New South Wales. Perhaps he did! James Ruse was a very interesting character (de Belin, 2020). He was a Cornish farmer who, in 1782, at the age of 23, was caught, tried and convicted for “*burgulariously breaking and entering the dwelling house of Thomas Olive about 1 in the night and stealing thereout 2 silver watches value 5 pounds and other goods value 10 shillings*”. He avoided the death penalty by accepting transportation to Australia for a term of 7 years! He wallowed on a prison hulk in Plymouth (Figure 5) for 5 years before embarking on the ‘Scarborough’ with the First Fleet.

By July 1789, the end of the term of his 7-year sentence had been reached, although Governor Phillip lacked any documentary evidence that this was indeed the case. After several of James Ruse’s pleas as to his term ending, Governor Phillip relented and permitted Ruse, in November 1789, to occupy and farm a 30-acre plot of land at Rose Hill, near Parramatta. James Ruse was after all a farmer. The plot of land was called “Experiment Farm”. Governor Phillip was keen to have James Ruse succeed and be an example and inspiration for other emancipated ex-convicts who would be rewarded with land grants if they displayed the industry and determination for the hard work needed to farm and grow food for the colony. James Ruse was so successful that after 12 months he was self-sufficient and free of the need for supply from the Government Stores. Shortly thereafter, James Ruse’s Experiment Farm was supplying hundreds of bushels of grain to the Government Stores.

Figure 4: Image of grant by Arthur Phillip to James Ruse – 22 February 1790 (see Appendix A for transcription).

Figure 5: Painting showing de-masted prison hulks at Plymouth with a transport ship anchored beside.

Of interest in the James Ruse saga is that the date written on his actual land grant parchment is clearly 22 February 1790. There were 51 other grants signed off on 22 February 1792. So, was the grant to James Ruse deliberately backdated to 1790 in order to reflect the fact that he had indeed been occupying and cultivating the land since November 1789? This would be proof that James Ruse was the first ex-convict to receive a land grant. Written on the reverse side of Ruse's grant is the deed of conveyance of the title for "Experiment Farm" to Mr John Harris, for the sum of 40 pounds, in October 1793 (Figure 6). This is a fine example of an early chain of title directly linking back to the first grant. It could also be explained by a shortage of parchment in those early days. Also note the deterioration of the medium, the fading of the ink and the evidence of poor storage, with water damage causing ink runs; all features of early deeds and dealings which render them sometimes almost completely unreadable and indecipherable.

The first female to receive a Crown grant is listed as Eleanor Frazer, who gained ownership of 20 acres near Concord on 20 February 1794. As an aside, she was a First Fleeter whose son John was the second child born in the new colony.

Figure 6: Reverse side of grant to James Ruse, showing first conveyance of his land to Mr John Harris – October 1793 (see Appendix B for transcription).

One of the first maps was produced in the colony in 1796, after a survey by Charles Grimes and Matthew Flinders. This map was reproduced and enhanced in 1798 (Figure 7).

Figure 7: Two early maps of the Sydney settlement – dated 1796 and 1798.

The heading on each map bears the following text:
"*The dotted lines show the ground walked over lately.*
⊙ *Are places where the latitude has been observed.*
Those places marked thus (green hatch) are the principal part of our cultivation."

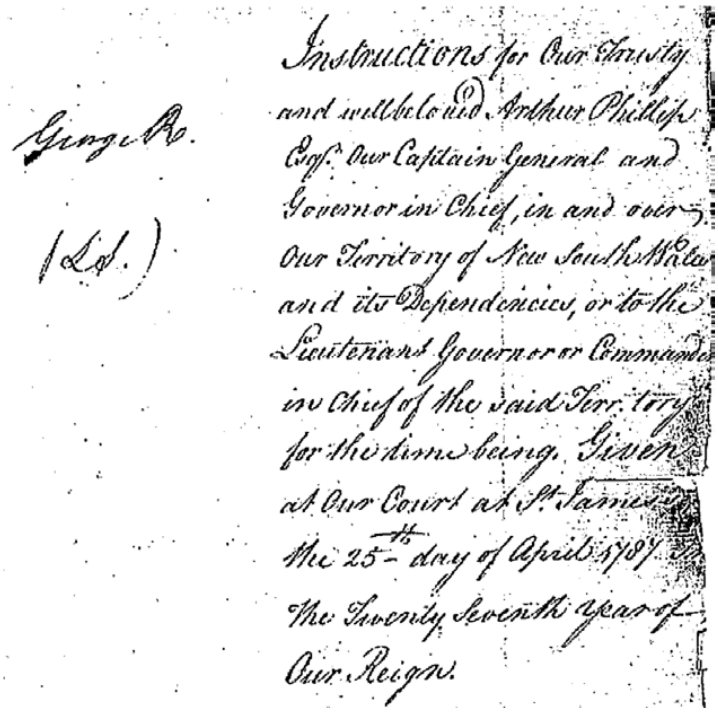
These early maps show how the settlement has spread from the Parramatta River, then west to the Hawkesbury River and south towards the Camden area. These two maps obviously are derived from the same source material. Detail from the 1796 map shows the first grants at the Field of Mars and the Eastern Farms (Figure 8). Notice with the very first grants at Ryde that some run right from the shoreline, while others are set back from the shoreline.

There are two reasons for this. Firstly, the positioning enables proper rectangles of land to be created and granted. Secondly, this land between the shoreline and the first grants was then used to provide a wharf and a marshalling area, so farm produce could be sent downstream to market at Sydney Cove. This is another fine example of an undefined area of Crown land being used for a specific public purpose. Can this land be considered alienated from the Crown Estate because of its usage?

Figure 8: Detail showing first land grants (in green) along Port Jackson and the Parramatta River between Sydney Cove and Parramatta – from 1796 map.

3 THE WORDING OF THE FIRST GRANTS

Governor Arthur Phillip acted under strict and explicit instructions from King George III when it came to granting land in the new colony (Figure 9).



George R.

(L.S.)

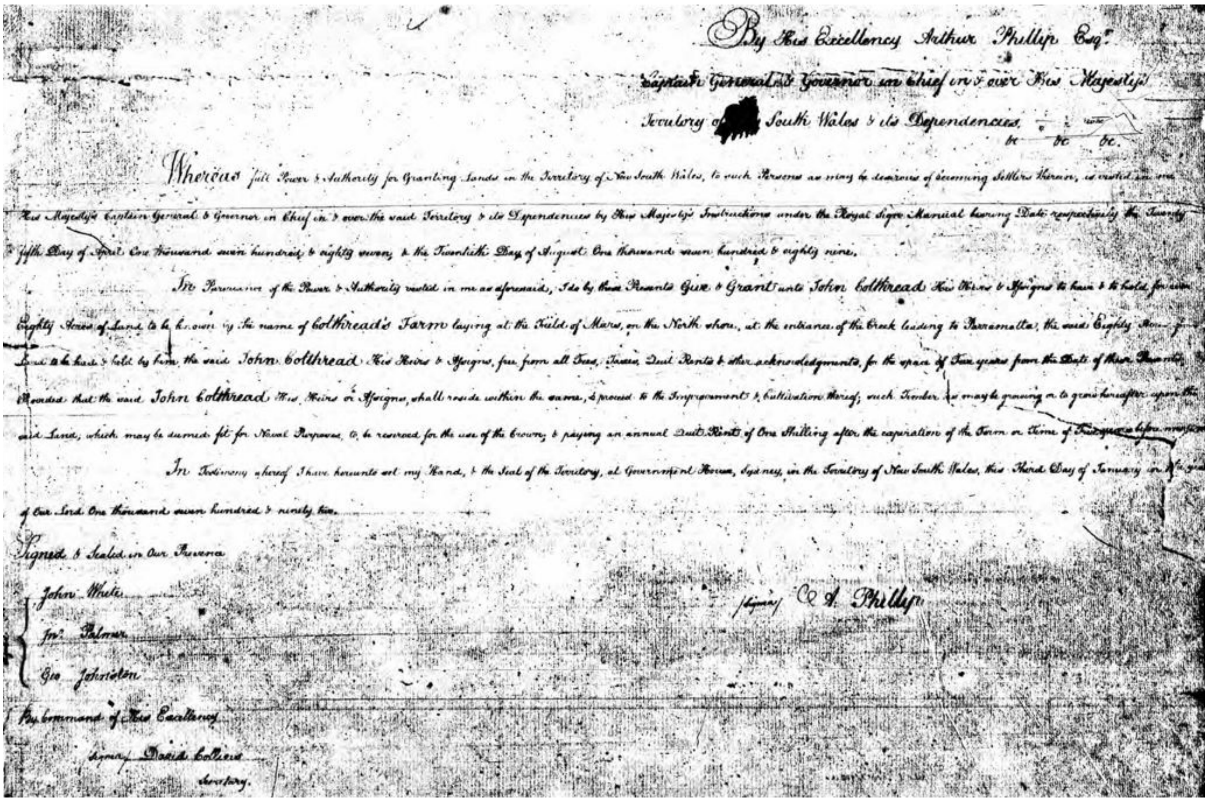
Instructions for Our Trusty and wellbeloved Arthur Phillip Esq.r Our Captain General and Governor in Chief, in and over Our Territory of New South Wales and its Dependencies, or to the Lieutenant Governor or Commander in Chief of the said Territory for the time being. Given at Our Court at St James's the 25th day of April 1787 the Twenty Seventh year of Our Reign.

Figure 9: Detail from first page of King George III instructions to Arthur Phillip – 1787.

The following is a transcription of selected parts of the King's instructions describing the granting of land in the new colony:

"… given and granted upon you full power and authority to emancipate and discharge from their servitude, any of the convicts under your superintendence who shall, from their good conduct and a disposition to industry, be deserving of favor [sic]: It is our will and pleasure that in every such case you do issue your warrant to the Surveyor of Lands to make surveys of and mark out in lots such lands upon the said territory as may be necessary for their use; and when that shall be done, that you do pass grants thereof with all convenient speed to any of the said convicts so emancipated … ***free of all fees, taxes, quit rents, or other acknowledgements whatsoever, for the space of ten years****:* ***Provided that*** *the person to whom the said land shall have been granted* ***shall reside within the same and proceed to the cultivation and improvement thereof; reserving only to us such timber as may be growing, or to grow hereafter, upon the said land which may be fit for naval purposes, and an annual quit rent of*** *[blank in manuscript]* ***after the expiration of the term or time before mentioned*** *… And whereas it is likely to happen that the convicts who may after their emancipation, in consequence of this instruction, be put in possession of lands will not have the means of proceedings to their cultivation without the public aid; It is our will and pleasure that you do cause every such person you may so emancipate to be supplied with such a quantity of provisions as may be sufficient for the subsistence of himself, and also of his family, for twelve months, together with an assortment of tools and utensils, and such a proportion of seed-grain, cattle, sheep, hogs, &c., as may be proper, and can be spared from the general stock of the settlement."*

The highlighted text is repeated, word for word, within the first grants issued by Governor Arthur Phillip (Figure 10).



By His Excellency Arthur Phillip Esqr.
Captain General & Governor in Chief in & over His Majesty's
Territory of [illegible] South Wales & its Dependencies.
&c &c &c.

Whereas full Power & Authority for Granting Lands in the Territory of New South Wales, to such Persons as may be desirous of becoming Settlers therein, is vested in me His Majesty's Captain General & Governor in Chief in & over the said Territory & its Dependencies by His Majesty's Instructions under the Royal Sign Manual bearing Date respectively the Twenty fifth Day of April One thousand seven hundred & eighty seven, & the Twentieth Day of August One thousand seven hundred & eighty nine.

In Pursuance of the Power & Authority vested in me as aforesaid, I do by these Presents Give & Grant unto John Colthread His Heirs & Assigns to have & to hold for ever Eighty Acres of Land to be known by the name of Colthread's Farm laying at the Field of Mars, on the North shore, at the entrance of the Creek leading to Parramatta; the said Eighty Acres of Land to be had & held by him the said John Colthread His Heirs & Assigns, free from all Fees, Taxes, Quit Rents & other acknowledgments, for the space of Ten years from the Date of these Presents. Provided that the said John Colthread His Heirs or Assigns, shall reside within the same, & proceed to the Improvement & Cultivation thereof; such Timber as may be growing or to grow hereafter upon the said Land, which may be deemed fit for Naval Purposes, to be reserved for the use of the Crown; & paying an annual Quit Rent of One Shilling after the expiration of the Term or Time of Ten years before mentioned.

In Testimony whereof I have hereunto set my Hand, & the Seal of the Territory, at Government House, Sydney, in the Territory of New South Wales, this Third Day of January in the year of Our Lord One thousand seven hundred & ninety two.

Signed & Sealed in Our Presence
John White
Jno. Palmer
Geo Johnston

(Signed) A. Phillip

By Command of His Excellency
(Signed) David Collins
Secretary.

Figure 10: Image of Colthread's original 80-acre grant from Governor Arthur Phillip – 3 January 1792.

The following is a full transcription of the land grant to John Colthread, showing the typical wording of grants signed off by Arthur Phillip as Governor.

"By His Excellency Arthur Phillip Esquire
Captain General and Governor in Chief in and over His Majesty's
Territory of New South Wales and its Dependencies

Whereas Full Power and Authority for Granting Lands in the Territory of New South Wales to such persons as may be desirous of becoming settlers therein, is vested in His Majesty's Captain General and Governor in Chief in and over the said Territory and its Dependencies by His Majesty's Instructions under the Royal Sign Manual, bearing date respectively the Twenty Fifth day of April, one thousand seven hundred and Eighty Seven, and the Twentieth day of August, one thousand seven hundred and Eighty Nine.

In pursuance of the Power and Authority vested in me as aforesaid, I do by these Presents Give and Grant unto John Colthread his heirs and assigns to have and to hold for ever, Eighty acres of land to be known by the name of Colthread's Farm, laying at the Field of Mars, on the North shore, at the entrance of the creek leading to Parramatta, the said Eighty acres of land to be had and held by him the said John Colthread his heirs and assigns ***free from all fees, taxes, quit rents and other acknowledgements for the span of five years*** *from the date of these presents,* ***provided that*** *the said John Colthread his heirs and assigns,* ***shall reside within the same and proceed to the Improvements and Cultivation thereof, such Timber as may be growing or to grow hereafter upon the said land which may be deemed fit for Naval purposes, to be reserved for use of the Crown, and paying an Annual Quit Rent of one Shilling after the expiration of the term or time of five years before mentioned****.*

In testimony whereof I have hereunto set my Hand, and the Seal of the Territory, at Government House, Sydney, in the Territory of New South Wales, this Third day of January, in the year of our Lord One thousand Seven hundred and ninety two.

Signed and Sealed in our presence.
John Palmer *signed A Phillip.*
George Johnston
John White
By command of His Excellency
Signed David Collins
Secretary."

The first crown grants (signed off by Governor Phillip) contained only information on parcel area, site location and an identity (generally the name of the owner, e.g. "Archer's Farm"). No metes, no bounds! The grants were made to marines, soldiers, emancipated convicts and some free settlers. William Paterson, as the caretaker Governor upon the return of Arthur Phillip to England in 1793, maintained the wording used in the first Crown grants when he continued issuing grants from the Crown Estate.

When Francis Grose became caretaker Governor after William Patterson, he found it necessary to affix an additional paragraph to the wording of a first Crown grant. Without blaming James Ruse directly, he was certainly one of the culprits when it came to forcing this change in grant wording. The James Ruse conveyance to John Harris in 1793 (see Figure 6) effectively removes any obligation that the new landowner may have towards the Crown with regards to the payment of quit rent, fees and taxes. The new inserted paragraph states that any sale or conveyance of the land made before the end of any set term shall be void and the said lands will revert to the Crown. The following detail from the grant to Ann Thorne (19 November 1794) shows the added paragraph:

> "*In pursuance of the Power and Authority vested in me as aforesaid, I do by these Presents Give and Grant unto Ann Thorne …*
> *… **And it is hereby provided that the said Ann Thorne shall reside upon and cultivate the lands hereby granted for and during the term of five years from the date hereof provided the said Ann Thorne shall so long live and any sale or conveyance of the said land before the expiration of the said term of five years shall be void and the said lands shall in such case revert to his Majesty His Heirs and Successors** …*
>
> *signed Francis Grose.*"

When Captain John Hunter undertook the role of Governor after Francis Grose, he modified the wording of the Crown grant still further to include abuttals in the land description (still no mention of measurements for bearing or distance though!). This is shown in the following detail of abuttals from the grant to William Balmain (3 August 1799):

> "***Bounded** on the South West side by an allotment granted to John Colthread,*
> *(bounded) on the South by the Flats …*
> *(bounded) on the North East by a line running from the South West corner of Meriam Hill to the head of the salt water creek on the West side of Dinner Point and*
> *(bounded) by an allotment of one hundred and five acres granted to Mr Balmain and*
> *(bounded) on the North West by an allotment granted to Thomas Douglas …*"

Not all grantees remained living on their parcel. Many grants were abandoned after a short time, and the subject land parcel was re-granted to a fresh settler in a next wave of enthusiasm for land ownership (Figure 11). In such a case, is the fresh grant, of the same 30-acre parcel, a second alienation of the same land? Where ownership has changed, as in the conveyance from Ruse to Harris, has an alienation occurred? Can a demarcation of Crown land for a special or specific purpose such as a road reservation, recreation reserve, drainage reservation or lease be considered an alienation?

Mr Surveyor John James Gallaway, in his survey (Crown Plan 1.1299) of the Field of Mars Common in 1847, demarcates and identifies 36 parcels of land being illegally occupied within the Common. As Gallaway notes (see Appendix C), some of these occupancies date back as far as 1802. Subsequently, Crown Plan 15.440 by Charles Scrivener in 1882, which is also a survey of the same Field of Mars Common, shows many of these occupancies still existing; now 70 years after 1802. Do illegal land grabs qualify as alienation? For major pirate activity with respect to land grabs, perhaps we should refer to the squatters in the outer districts and beyond the 19 counties (a topic not covered in this paper).

Figure 11: Parish of Hunters Hill, showing location of the first grants in Ryde from 1792 to 1809 – 1875 map.

4 MEASURING AND MARKING THE FIRST GRANTS

How were the first grants measured and marked? It is most likely that the first surveying instruments available in the colony were the compass (circumferentor) and the Gunter's chain (Figures 12 & 13). The circumferentor had appeared in Germany in the early 1500s, whereas Gunter's chain was developed in 1620 by an English astronomer and mathematician named Edmund Gunter. Both surveying tools were used in tandem for 250 years and were certainly the instruments of choice by the early surveyors in New South Wales. However, these instruments had a few drawbacks which limited their accuracy. For example, the circumferentor did not tilt, so accurate observations on very sloping ground were very difficult.

Figure 12: Circumferentor.

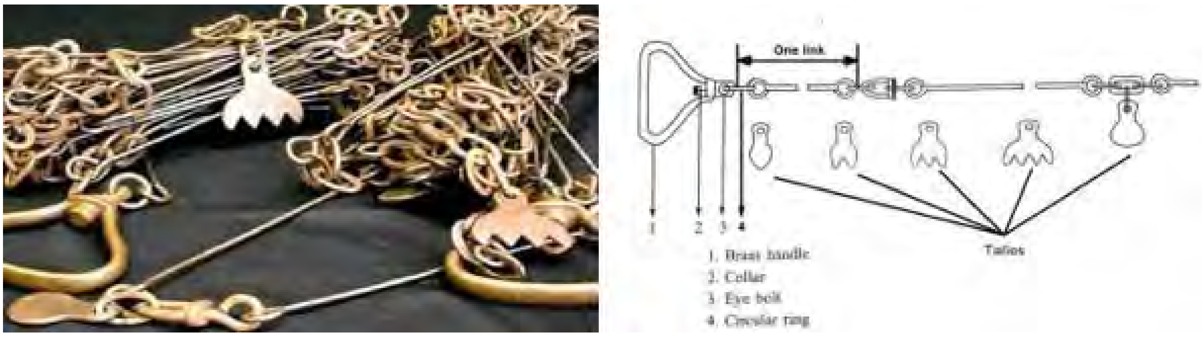


Figure 13: Gunter's chain, together with diagram showing the markings along the chain.

In 1812, John Oxley as Surveyor General, made a request for a common measuring wheel. Measuring wheels or perambulators (Figures 14 & 15) were certainly being used in India prior to 1800 as a relatively quick means of roughly checking a baseline calculation. John Meehan, in his 1818 exploration through the southern highlands and southern tablelands "measured with a perambulator", as he wrote at the beginning of his field notes.

Figure 14: Wooden measuring wheel or perambulator, showing clocklike tally mechanism – early 1800s.

Figure 15: Metal measuring wheel or perambulator, showing distance tally mechanism – mid 1800s.

This metal measuring wheel from the Queensland Museum of Lands Mapping and Surveying has a diameter of 25¼ inches, which results in a wheel circumference of 6.6 feet. Thus, ten revolutions of the wheel equals 66 feet or 1 chain! Similarly, if a measuring wheel has a diameter of 42 inches (3½ feet), then the wheel circumference is 11 feet. Thus, six revolutions of the wheel equals 66 feet or 1 chain! This type of Measuring wheel was still being used for surveys in outback Queensland in the 1880s.

There was a dearth of land surveyors in the early years of first settlement. Some of the notable land surveyors in the early years of the colony included Charles Grimes, John Meehan, John Oxley, George Evans and John James Gallaway. The earliest available field notes were provided by Grimes from 1794, which include entries about using a compass, measurements being made in chains and describing the type of marking. There are constant references to starting at a known or established corner, although there are no indications of what marked that corner. How did the early surveyors mark parcel corners? As would probably be predicted, new corners were marked with a stake or a drilled hole in rock or a tree marked on four faces (Figure 16).

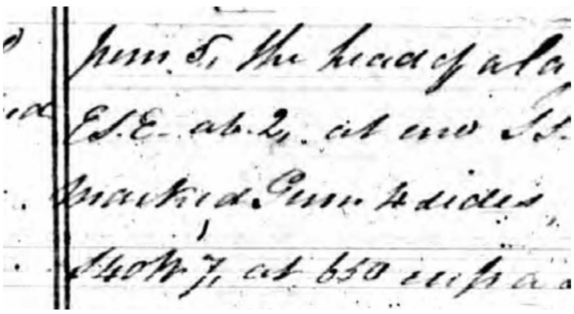


Figure 16: Line in Grimes' field notes, showing "marked Gum 4 sides" indicating a tree on corner – 1796.

During Meehan's expeditionary traverse in 1818 to locate and investigate a route from Camden to the Shoalhaven River, a tree was marked at the end of each day to indicate the start point for the first traverse leg of the next day. In 1838, 50 years after the arrival of the First Fleet, the town boundary of Parramatta was surveyed by John James Gallaway and marked with such diverse items as five stakes, a grey gum tree, a large dead stump on a hill, a post of a small bridge, another dead stump, then natural boundaries along a ridge and finally along a creek. So, tree marking was still considered an easy first option (Figure 17).

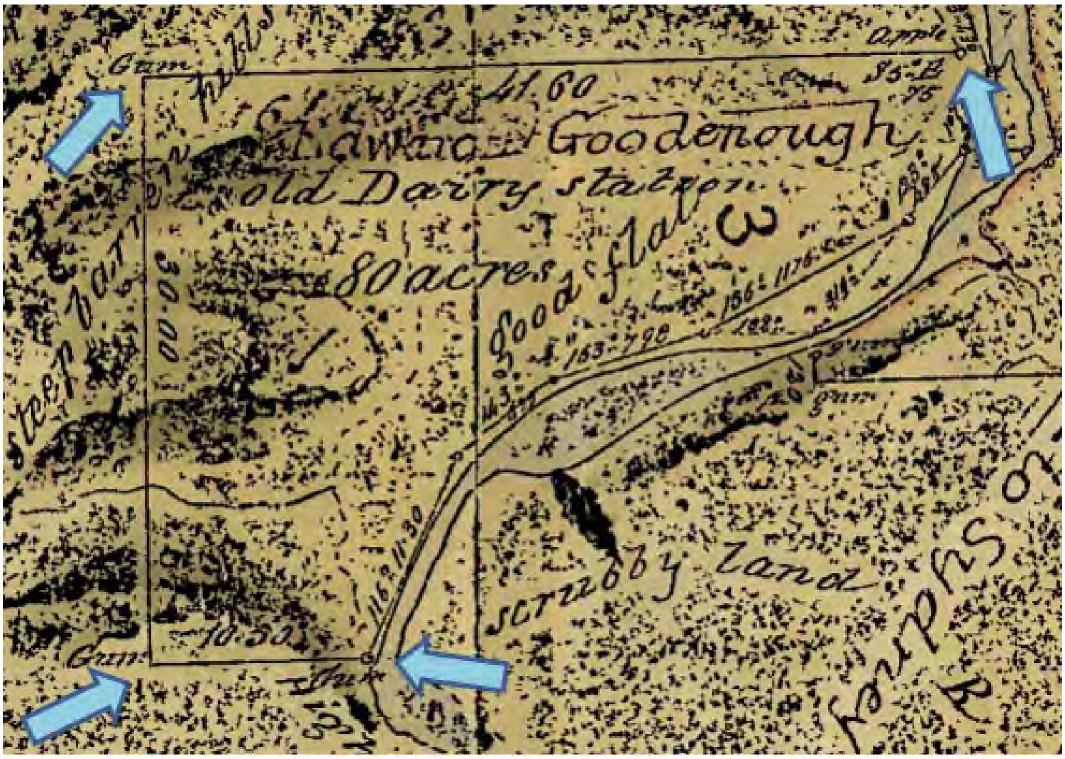


Figure 17: Plan of Portion 3, Parish of Nattery, County Argyle, showing trees marking each corner – 1855.

"Gum Stump", "Large Oak Stump", "Large Dead Tree" and "Stump" are all shown by Gallaway on Crown Plan 1.1299 as indicating old grant corners. Other notations on Gallaway's plan include "Well marked line but not very straight" and "Line marked by some private surveyor in mistake". My favourite notation is a description of an irregular parcel which is "girt in by rocks", surely an apt Australian expression (see Appendix D).

The first recorded directions to all surveyors came from Surveyor General Mitchell in 1836, at a time when the Surveyor General's Department consisted of 14 assistant surveyors. He stated "*… that the marking and measuring of the portions of land applied for as purchases are conducted by some of the surveyors in a very loose, inaccurate and unsatisfactory manner … – I have to point out to you that – altho' even in the measurement of a grant (a gift from the Crown) such looseness could scarcely be tolerated.*" Lands Department specifications for corner marking first appeared in 1848.

5 LAST GRANT IN NEW SOUTH WALES

The last Crown grant of land in New South Wales occurred in 1981, with Bruce Davies, the NSW Registrar General at the time, ceremoniously handing a title to the trustees of St Vincent's Hospital in Darlinghurst, Sydney. The land parcel involved was sited in Barcom Street and already occupied by hospital buildings. Could this be a final recognition of a land grab and alienation? With this last grant and alienation came the realisation that any unalienated Crown land should revert to Native Title and be administered by various Aboriginal Land Councils. This process of identifying unalienated land and lodging a valid claim for the land is ongoing. Once again a question arises: Is the reversion of Crown land to Native Title an alienation? Or is it an atonement for an earlier wrongdoing and land theft?

6 CONCLUDING REMARKS

It is hoped that this paper has provided some food for thought in the quest to answer the posed questions relating to first grants and alienation. All who now reside in the City of Ryde live on land that was once the domain of a group of wandering Aborigines named the Wallumattagal (Smith, 2005). This group moved through their territory leaving very little evidence of their existence except for scattered rock carvings and shell middens and a concept of land 'ownership' incomprehensible to the British colonists who landed in 1788. This lack of understanding led to the new settlers believing that the land belonged to no one and was solely theirs to use. Thus, the British concept of land ownership came to the colony, in which individuals owned a designated parcel of land to provide for themselves, their family and community or society.

What became of the Aboriginal inhabitants who populated the Sydney and Parramatta area at the time of first European settlement and first alienation of their traditional lands? For the first 20 years, their presence was abundantly obvious with continuous contacts, reports of their comings and goings and exchanges. The Sydney Gazette regularly carried stories about prominent Aboriginal leaders and their welfare, with reference to internal fights, native justice and the native way of life. Government officers attempted to gather as much information as possible in respect to Aboriginal language, Aboriginal custom, culture, heritage and learning. Surveyors and explorers never set off into the unknown bushland without some Aboriginals in accompaniment as guides and holders of bush knowledge. Prominent citizens recorded many contact anecdotes in their personal memoirs and diaries. By 1838, however, there is one poignant note in a written account by William Lawson, of Blue Mountains explorer fame: "… *with his tribe at Kissing Point which are all now – I believe nearly extinct…*"

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Smith K.V. (2005) *Wallumedegal: An Aboriginal History of Ryde*, City of Ryde, Sydney, ISBN 0-95994-19-9-1, https://www.ryde.nsw.gov.au/files/assets/public/library/wallumedegal-an-aboriginal-history-of-ryde.pdf (accessed Mar 2023).

APPENDIX A

Transcription of James Ruse land grant dated 22 February 1790 [1792]:

"By His Excellency Arthur Phillip Esquire
Captain General and Governor in Chief in and over His Majesty's
Territory of New South Wales and its Dependencies

Whereas Full Power and Authority for Granting Lands in the Territory of New South Wales to such persons as may be desirous of becoming settlers therein, is vested in me His Majesty's Captain General and Governor in Chief in and over the said Territory and its Dependencies by His Majesty's Instructions under the Royal Sign Manual, bearing date respectively the Twenty Fifth day of April, one thousand seven hundred and Eighty Seven, and the Twentieth day of August, one thousand seven hundred and Eighty Nine.

In pursuance of the Power and Authority vested in me as aforesaid, I do by these Presents Give and Grant unto James Ruse his heirs and assigns to have and to hold for ever, thirty acres of land in one lot to be known by the name of Experiment Farm, laying on the south side of the Barrack Ponds at Parramatta the said thirty acres of land to be had and held by him the said James Ruse his heirs and assigns ***free from all fees, taxes, quit rents and other acknowledgements for the space of ten years*** *from the date of these presents,* ***provided that the*** *said James Ruse his heirs or assigns,* ***shall reside within the same and proceed to the Improvement and Cultivation thereof, such Timber as may be growing or to grow hereafter upon the said land which may be deemed fit for Naval purposes, to be reserved for use of the Crown****,* ***and paying an Annual Quit Rent of one Shilling after the expiration of the term or time of ten years before mentioned****.*

In testimony whereof I have hereunto set my Hand, and the Seal of the Territory, at Government House, Sydney, in the Territory of New South Wales, this twenty second day of February in the year of our Lord One thousand Seven hundred and ninety.
Signed and Sealed in our presence.

James Palmer *signed A Phillip.*
George Johnston
John White

By command of His Excellency
Signed David Collins
Secretary."

APPENDIX B

Transcription of James Ruse conveyance to Mr John Harris in 1793, which was written on the reverse side of the James Ruse grant:

These presents testify that I James Ruse the Grantee in the within Patent named, do hereby for and in consideration of the sum of Forty Pounds sterling to me paid, at or before the ensigning and delivery, of these presents The receipt whereof I hereby acknowledge [illegible] of and of every part thereof as hereby acquit [illegible] charge, Mr John Harris His Heirs, and Assigns, all that [illegible] thirty acres of land known by the name of Experiment Farm, laying on the south side of the Barrack Ponds at Parramatta, to hold to him the said Mr John Harris, His Heirs, and Assigns, in as full ample and beneficial as the same is granted, and conveyed, to me in and by Virtue of the within Grant, or Patent, hereby fully and unequivocally Relinquishing all Right Title Intrist [sic], Property Claim and Demand which I and my Heirs could Claim in or to the same Acknowledging to have received the aforesaid Sum of Forty Pounds sterling in full lieu [illegible] consideration of the same in witness wherof [sic] I have hereunto set my Hand and Seal this Twenty First day of October one thousand seven hundred and ninety three.

And delivered in presence
Read to me *freeman*
The aforesaid sum of forty pounds sterling being
Executing the foregoing deed

signed James Ruse.

APPENDIX C

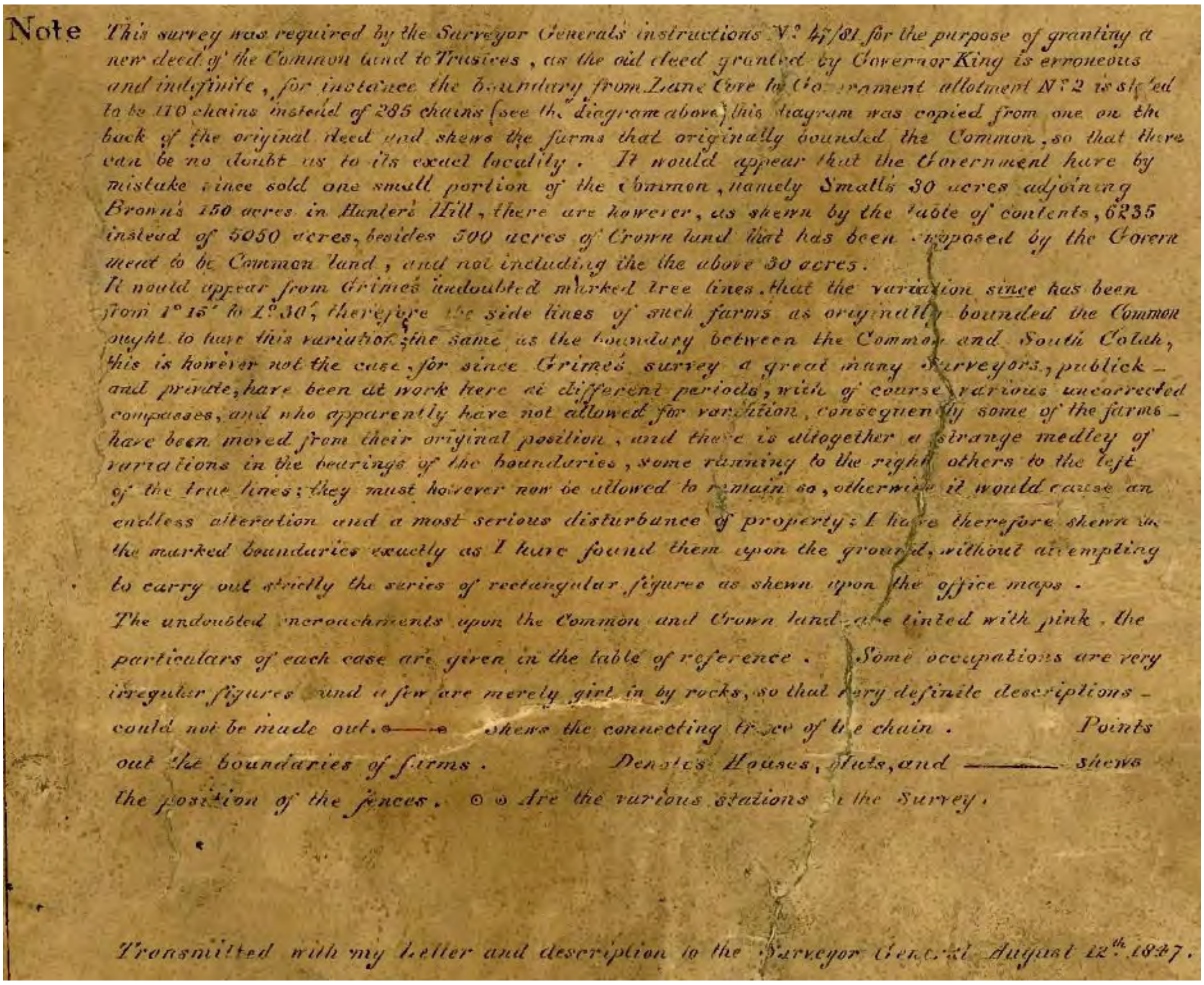
Transcription of the table of reference to the encroachments on the Common, which appears on Crown Plan 1.1299 of 1847. This is virtually a census snapshot of 36 'illegal' land occupiers within the Field of Mars Common. Figure 18 visualises the location of these encroachments.

No	**Area**			**Name**	**Occupation**	**Remarks**
1	0	3	0	T Small	--	Owner of Moore's Grant.
2	1	2	0	Barnar Rouke	--	Owner of part of Kent's 570 acres
3	3	3	0	Rev Mr Tarner	--	Owner of Weaver's Grant.
4	4	1	0	Mr Isaacs	--	Owner of (?) Grant.
5	1	3	20	P Dunn	13 years	Has a wife. He is employed cutting firewood.
6	0	2	15	James Blanchard	2 years	Supports a bedrid sister with three children.
7	0	0	4	Barney Kennedy	--	A erratic (?) who sometimes lives here in a hut under the rocks.
8	0	3	10	George Nelson	18 years	Married (?) Bell the widow of a former resident.
9	0	0	0	Joseph Tasker	--	A boatman? He only occupies a small hut.
10	2	3	20	William Martin	16 years	Has a wife and seven children; has a good garden.
11	0	1	30	William Adams	3 years	Has a wife and three children. Is an old surveyor's man.
12	0	0	0	John the broom-maker	--	Only occupies a hut.
13	0	3	0	William Baker	19 years	Has a wife and seven children.
14	0	0	10	William Kitchen	2 years	Has a wife and one child.
15	1	2	0	John Bowen	35 years	Has a wife. A very old woman
16	0	0	0	Archibald Noble	9 years	A widower with one child, lives in a hut under the rocks.
17	0	0	10	George (?)	1 year	Has a wife and three children.
18	0	0	0	William Gordon	13 years	A boatman (?) merely a hut.
19	1	0	0	James Ward	? years	Has a wife. A very old couple.
20	(?)	3	20	David Rodde	9 years	Has a wife and two children.
21	(?)	2	30	Charles Re(?)	2 years	Has a wife and three children. An American black.
22	2	3	0	Antonio (?)	1 year	Has a wife and two children.
23	5	1	0	William Ma(?)	25 years	Has a wife and children grown up; has an excellent orchard.
24	2	3	0	Henry Haynes	23 years	Has a wife. Joseph Ferrara sold to him the good will of the place.
25	2	3	10	Thomas (?)	11 years	Has a wife. Has a good orchard.
26	4	0	0	John (?)	17 years	Got it from (?)ineger about 12 months since.
27	0	3	20	William Murray	7 years	Has a wife.
28	20	2	0	Captain Bennet	--	Owner of Harding's Grant.
29	3	2	30	William Parsons	7 years	Has a wife and five children.
30	13	3	30	Thomas Small	--	Prop(rietor) of Kent's 170 acres
31	35	0	0	James Devlin	--	Prop(rietor) of Kent's 470 acres
32	4	2	0	(?) Small	9 months	Has a wife and six children.
33	1	2	20	Mary Martin	3 years	Is daughter of Black Randall; is now a widow with 12 children
34	0	3	20	Henry Cook	--	Leased part of Savage's Grant
35	8	1	20	(?) Thomson	--	Propri(etor) of Pinkhams Grant
36	3	3	0	Mathew Gollard	2 years	Has a wife and seven children; There is a grave upon it.
	138	1	19	Total		

Figure 18: Crown Plan 1.1299 showing locations of the encroaching occupations – 1847.

APPENDIX D

Transcription of a note that appears on Crown Plan 1.1299 of 1847. James Gallaway was the surveyor of this plan, and he comments on discrepancies that he has found when comparing to earlier surveys, especially the variation in compass bearing (Figure 19).



Note This survey was required by the Surveyor Generals instructions No. 47/81 for the purpose of granting a new deed of the Common land to Trustees, as the old deed granted by Governor King is erroneous and indefinite, for instance the boundary from Lane Cove to Government allotment No. 2 is stated to be 110 chains instead of 285 chains (see the diagram above) this diagram was copied from one on the back of the original deed and shews the farms that originally bounded the Common, so that there can be no doubt as to its exact locality. It would appear that the Government have by mistake since sold one small portion of the Common, namely Smalls 30 acres adjoining Browns 150 acres in Hunters Hill, there are however, as shewn by the table of contents, 6235 instead of 5050 acres, besides 500 acres of Crown land that has been supposed by the Government to be Common land, and not including the the above 30 acres.

It would appear from Grimes undoubted marked tree lines that the variation since has been from 1°15' to 1°30', therefore the side lines of such farms as originally bounded the Common ought to have this variation, the same as the boundary between the Common and South Colah, this is however not the case, for since Grimes survey a great many Surveyors, publick and private, have been at work here at different periods, with of course various uncorrected compasses, and who apparently have not allowed for variation, consequently some of the farms have been moved from their original position, and there is altogether a strange medley of variations in the bearings of the boundaries, some running to the right others to the left of the true lines; they must however now be allowed to remain so, otherwise it would cause an endless alteration and a most serious disturbance of property; I have therefore shewn in the marked boundaries exactly as I have found them upon the ground, without attempting to carry out strictly the series of rectangular figures as shewn upon the office maps.

The undoubted encroachments upon the Common and Crown land are tinted with pink. the particulars of each case are given in the table of reference. Some occupations are very irregular figures and a few are merely girt in by rocks, so that very definite descriptions could not be made out. shews the connecting trace of the chain. Points out the boundaries of farms. Denotes Houses, Huts, and shews the position of the fences. Are the various stations of the Survey.

Transmitted with my letter and description to the Surveyor General August 12th 1847.

Figure 19: Notation on John James Gallaway survey Crown Plan 1.1299 – 1847.

“*Note: This survey was required by the Surveyor General’s instructions No. 47/81 for the purpose of granting a new deed of the Common land to Trustees, as the old deed granted by Governor King is erroneous and indefinite, for instance the boundary from Lane Cove to Government allotment No. 2 is stated to be 110 chains instead of 285 chains (see the diagram above) this diagram was copied from one on the back of the original deed and shews the farms that originally bounded the Common, so that there can be no doubt as to its exact locality. It would appear that the Government have by mistake since sold one small portion of the Common, namely Small’s 30 acres adjoining Brown’s 150 acres in Hunter’s Hill, there are however, as shown by the table of contents, 6235 instead of 5050 acres, besides 500 acres of Crown land that has been supposed by the Government to be Common land, and not including the above 30 acres. It would appear from Grime’s undoubted marked tree lines that the variation since has been from 1 degree 15’ to 1 degree 30’, therefore the side lines of such farms as originally bounded the Common ought to have this variation, the same as the boundary between the Common and South Colah, this is however not the case, for since Grime’s survey a great many surveyors, publick [sic] and private, have been at work here at different periods,* *with of course various uncorrected compasses, and who apparently have not allowed for variation, consequently some of the farms have been moved from their original position, and there is altogether a strange medley of variations in the bearings of the boundaries, some running to the right others to the left of the true lines, they must however now be allowed to remain so, otherwise it would cause an endless alteration and a most serious disturbance of property; I have therefore shewn all the marked boundaries exactly as I have found them upon the ground, without attempting to carry out strictly the series of rectangular figures as shown upon the office maps. The undoubted encroachments upon the Common and Crown Land are tinted with pink, the particulars of each case are given in the table of reference. Some occupations are very irregular figures and a few are merely girt in by rocks, so that very definite descriptions could not be made out. (Line symbol) Shews the connecting trace of the chain. (Line symbol) Points out the boundaries of farms. (Symbol) Denotes houses, huts, and (Line symbol) shews the position of fences. (Dot symbols) Are the various stations in the survey.*

Transmitted with my letter and description to the Surveyor General August 12th 1847."

When a Border Becomes a Boundary

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ABSTRACT

The proposed duplication of the Barton Highway from the Australian Capital Territory (ACT) border towards Murrumbateman in New South Wales (NSW) requires the acquisition of land to accommodate the project. Commencing at the ACT border provides a unique insight into the history surrounding the initial Federal Capital Territory border surveys commencing in 1910 and running through to 1915. This presentation examines the history, legislation and surveys that led to the Australian Capital Territory as we know it today. The resumption of land to create the ACT bisected many existing portions within NSW. Many of these portions had poor survey, so the first task was in fact to redefine each parcel of affected land. Thus the eventual border totalling 306 km in length required surveys that exceeded this distance many times over. An overview of the border survey campaign is followed by examining the historic and recent land surveys adjacent to the Barton Highway and ACT border.

KEYWORDS: *Border, boundary, land acquisition, Barton Highway*.

Assessing the Detectability of Underground Water Pipe Leaks with Non-Invasive Technologies

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ABSTRACT

Underground water leaks cost Australian utility providers approximately $840 million a year nationally in lost revenue. In this paper, the capabilities and limitations in applying Ground Penetrating Radar (GPR), infrared (IR) thermal and multispectral sensor Unmanned Aerial Vehicles (UAVs or drones) are determined by simulating underground water pipe leaks at varying depths (0.2 m, 0.3 m, 0.45 m). The presence of water manifested itself as an alteration to the soil's dielectric constant, resulting in a deepening of the pipe in comparison to the actual pipe depths on the GPR scans. This phenomenon was observed at all pipe depths from as early as one hour after beginning the leaks. The presence of water at the surface from the 0.2 m deep pipe leaks resulted in a decrease in surface temperature, allowing leak identification to occur from the thresholds determined. The IR thermal images were unable to identify leaks on the 0.3 m and 0.45 m deep pipes. Temperature-Vegetation Dryness Index (TVDI) images generated from the multispectral band images were inconclusive in identifying leaks. GPR and the 0.2 m deep pipe had the highest correctly identified leak detection rates. This research has generated a deeper understanding of employing these non-invasive technologies in leak detection, offering an efficient, low-cost option compared to current standard leak detection techniques.

KEYWORDS: *Ground Penetrating Radar, UAV, leak detection, non-invasive.*

1 INTRODUCTION

In Australia, it is estimated that on average 10% of all the water fed into the water networks by utility providers is lost due to leaks in the underground pipe networks (Water Services Association of Australia, 2020). With water being a finite resource in Australia due to drought conditions, the need to identify these leaks reliably and efficiently is a topic of interest to not only the utility providers but the country as a whole. It was estimated that water lost throughout the water distribution network cost the utility providers in the south-east Queensland region approximately $117 million in the 2020-21 financial year (Australian Government, 2021). As the south-east Queensland region makes up only approximately 14% of the national population (Australian Bureau of Statistics, 2023), these figures equate to approximately $840 million in revenue nationally lost to water leaks.

The main source of water that feeds these networks around the country are rivers and streams, which are mainly fed from rainfall. The Bureau of Meteorology is predicting reductions in precipitation of between 1% and 8% for the south-east Queensland region (Australian Government, 2023), and this reduction in rainfall could lead to less water being input into the water networks, leading to water shortages, further increasing the need to reduce water losses.

Current practice to detect leaks is a combination of monitoring district areas during low times of usage (i.e. late night) with data loggers to identify potential leaks and then employing leak detection tools such as electro-acoustic devices and closed-circuit television to locate the leaks (De Coster et al., 2019). These processes can involve disruptions to the supply network, generating further costs for the utility providers, and generally require destructive techniques such as excavation to confirm the leaks once identified (Aslam et al., 2018). With the integration of infrared (IR) thermal cameras and multispectral (MS) sensors on Unmanned Aerial Vehicles (UAVs or drones) and the availability of smaller, easily portable and affordable Ground Penetrating Radar (GPR) units, these non-invasive technologies, not typically used in leak detection, could provide an efficient, low-cost option in identifying leaks in the underground water pipe networks.

1.1 Ground Penetrating Radar

GPR works by emitting electromagnetic pulses from a transmitter, which travel through the subsurface material with objects within the subsurface reflecting that signal back. The types of material that the emitted waves travel through will affect transmission velocity, with different materials having different dielectric constants (or relative permittivity) (Utsi, 2017). The presence of water within the subsurface should alter the relative permittivity of the soil, resulting in slower transmission speeds which will normally manifest as targets appearing deeper within the subsurface than expected. It is this phenomenon that is tested to detect water leaks in underground pipes.

The use of GPR to detect underground leaks has been widely researched with its use also being combined with other processes such as IR thermal imaging (Atef et al., 2016; Khader, 2016; Hawari et al., 2017) where GPR has been used to assist in determining the location of the underground pipe. Lai et al. (2016), Aslam et al. (2018), De Coster et al. (2019) and Aslam et al. (2022) all conducted experiments within a sand medium, while Cataldo et al. (2014) tested if different soil types had any effect on the detectability of the water leaks by conducting their experiment within a clayey soil and a silty soil. Cataldo et al. (2014) showed that soil type influenced the propagation speed of the emitted wavelength, affecting the radargrams produced. A variety of pipe materials has been tested, with Lai et al. (2016) and Aslam et al. (2022) both assessing the effect different materials have on the detectability of the water leaks. Metallic, polyvinyl chloride (PVC), polypropylene (PPR) and polyethylene (PE) have been covered between the two experiments, with the research showing that pipe material had little effect on the ability of GPR to detect the water leaks.

1.2 Infrared Thermal Imagery

Infrared thermal imaging is a process that captures the temperature of objects by detecting emitted radiation from the object in the IR range of the electromagnetic spectrum and converting this value to a temperature value using the Stefan-Boltzmann law (Thusyanthan et al., 2016). Depending on the time of year, weather conditions, soil type, pipe material and depth, the water within the pipe will generally be warmer or cooler than that of the surrounding material. As a leak occurs, the temperature of the waterlogged soil surrounding the pipe should increase or decrease compared to the temperature of the dry soil (Shakmak and Al-Habaibeh, 2015), allowing these areas to be identified from the IR thermal images.

Infrared thermal imagery has been applied to the detection of underground leaks in a variety of simulated and existing conditions as a standalone process and coupled with GPR and MS imagery (Huang et al., 2010; Atef et al., 2016; Khader, 2016; Hawari et al., 2017). Atef et al. (2016), Khader (2016) and Hawari et al. (2017) all conducted controlled experiments testing what effects flying height and flying speed had on the ability of IR thermal imagery to detect underground leaks. Both Khader (2016) and Hawari et al. (2017) found that a camera height of 1 m and a flying speed of 2 km/h (0.28 m/s) was optimal for their experimental conditions, while the research conducted by Atef et al. (2016) concluded that a camera height of 2 m and a flying speed of 1.65 m/s was optimal. These differences are likely the result of variations in the surfaces and surrounding environments used within the respective experiments and are consistent with the findings of Hawari et al. (2017) who found that the three characteristics that impact the IR camera's ability to detect leaks are surface emissivity, surrounding environmental conditions (ambient temperature and relative humidity) and the operating conditions of the camera (flying height and flying speed). Emissivity is a ratio of a surface's ability to radiate energy at a temperature compared to that of a black surface (considered a perfect emitter) at the same temperature and will vary for different surfaces (Li et al., 2013).

Hawari et al. (2017) also found that slower flying speeds and lower heights were more suitable for surfaces with low emissivity and environments with low ambient temperatures and relative humidity. For high emissivity surfaces and high ambient temperatures and relative humidity, faster flying speeds helped to reduce noise due to the surrounding environmental conditions and the camera height having minimal effect on the results. This may explain the difference in operating conditions found by Atef et al. (2016) as the surface tested was a brick surface that has a high emissivity (Engineering ToolBox, 2003) and was conducted in high ambient temperatures (humidity was not noted).

1.3 Multispectral Imagery

Multispectral imaging is the process of collecting images in a combination of bands including visible, near infrared (NIR) and thermal infrared wavelengths and creating composite images from different combinations (Huang et al., 2021). Various indices generated from multispectral imagery have been used in leak detection. Initial research into leak detection concentrated on using the Normalised Difference Vegetation Index (NDVI) (Huang et al., 2010; Agapiou et al., 2016) and progressed to the Temperature-Vegetation Index (T-VI) (Chatelard et al., 2019; Krapez et al., 2020, 2022), which inspired the concept of employing the Temperature-Vegetation Dryness Index (TVDI) for leak detection (Sandholt et al., 2002; Chen et al., 2011).

Huang et al. (2010) used NDVI to identify potential areas of seepage or leaks within irrigation canals by visually assessing the images for areas with higher NDVI values compared to the surrounding areas as evidence of leaks present. They also found that NDVI was useful to eliminate false positives when used in combination with other sources such as thermal imagery where factors such as shadows can result in falsely identified areas. Agapiou et al. (2016) developed an automated process to assess NDVI images over an existing water pipe with a known leak site. By determining thresholds for the NDVI values from data taken with a spectroradiometer in the field, the NDVI images were assessed with any pixels within the determined thresholds identified as a potential leak site. NDVI images taken over a period of time were also assessed where any difference in NDVI values between images indicated an area as a potential leak site. Both studies showed that NDVI can been successfully applied to leak detection in different situations with varying levels of success. However, their research indicates that this application is more suited to sites where the leak has been present for extended periods, allowing for the surrounding vegetation to grow and thrive on the water leaked from the pipe, returning higher greenness values.

T-VI, also referred to as the 'triangle method' named for the triangle-shaped scatterplot that is generated when a full range of varying soil moisture content and vegetation cover is represented in the dataset (Krapez et al., 2020), has been widely researched with similar methodologies to those employing NDVI utilised to identify leak locations. T-VI is computed using a combination of surface temperature determined from thermal imagery and a vegetation index (typically NDVI or Optimised Soil Adjusted Vegetation Index, OSAVI). Each pixel in the image is plotted with temperature as a function of a vegetation index to develop a scatterplot where pixels nearing the wet edge are thought to have higher moisture content compared to pixels near the dry edge (Chen et al., 2011). T-VI is applied to the detection of water leaks using the same principles as NDVI, where the presence of excess water from an underground leak has caused the surrounding vegetation to thrive, thus returning a stronger signal in the red and NIR bands when captured with a multispectral camera. The addition of the surface temperature component further improves the detectability of these wet areas by being able to differentiate between the 'dry' healthy vegetation areas and the 'wet' healthy vegetation areas.

Chatelard et al. (2019) and Krapez et al. (2020) employed the triangle method to identify potential leak sites with a Water Index (WI) over underground water pipes, with Chatelard et al. (2019) setting up an experiment over a simulated leak and Krapez et al. (2020) over an existing water pipe. Both experiments were able to positively identify (albeit not definitively) potential leak sites by analysing the generated WI images for areas with higher WI values. Both studies identified that while the experiments were able to identify the leak sites, factors such as shadows and the time of day/year that the images are captured influenced the ability to positively identify these potential leak sites since the Water Index is reliant on the surface temperature computed from the thermal imagery. Chatelard et al. (2019) concluded that the application of the WI should be carried out in the warmer months and long after any rain periods to maximise the surface reflectance and subsequent surface temperature used in calculating it.

Krapez et al. (2022) applied two versions of the triangle method (NDVI vs. IR and OSAVI vs. IR) across a wide range of conditions both on simulated and real-world leaks. They initially researched and tested many different multispectral images (single bands and combinations of bands) to assess the effectiveness in identifying leaks in water pipes and found that the T-VI combinations (as well as straight thermal IR images) produced the best results. Chatelard et al. (2019) and Krapez et al. (2020, 2022) showed that T-VI can also be successfully applied to leak detection, but their research showed that results can be greatly affected by factors such as weather and shadows with the level of success being related to the time of day and year that the images are generated. In optimal conditions, T-VI may be more suitable to identify shorter-term leaks as it is influenced by the surface temperature, which will fluctuate more rapidly due to the presence of excess water in the soil from the underground leaks.

The Temperature-Vegetation Dryness Index (TVDI) is a modified version of T-VI, which was further simplified by Sandholt et al. (2002) so that the wet edge is held parallel to NDVI on the x-axis and the dry edge is computed as a line fit to the data (Figure 1) with the dry edge given a value of 1 and the wet edge a value of 0. TVDI has typically been used as a means of assessing vegetation and soil water stress due to drought conditions (Rahimzadeh-Bajgiran et al., 2012).

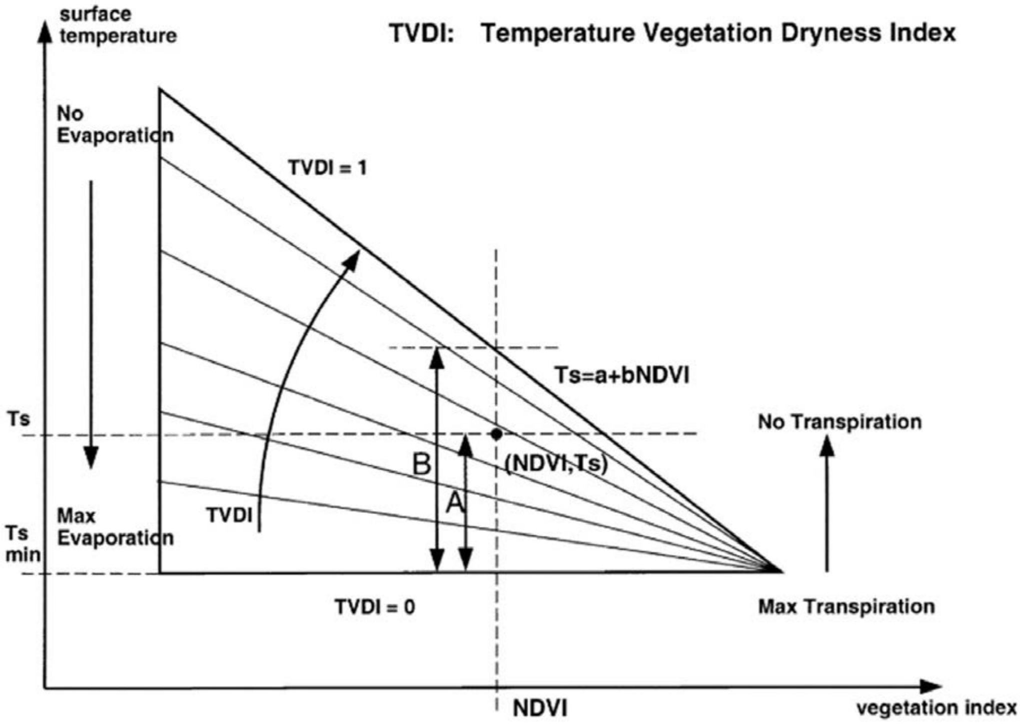

Figure 1: Graphical representation of TVDI. The triangle is turned on its side with NDVI held parallel to the x-axis and surface temperature on the y-axis (Sandholt et al., 2002).

Chen et al. (2011) applied a further modified TVDI in an experiment to determine the relationship between TVDI and soil moisture by statistically comparing TVDI values generated from multispectral satellite imagery against soil moisture values acquired from field studies. They applied a least-squares regression to statistically determine both the wet and dry edge, rather than holding the wet edge parallel to the x-axis. It was found that the TVDI values generated were a good indication of soil in the 10-20 cm depth range, but that TVDI poorly estimated soil moisture values in the 0-10 cm range. It was hypothesised that this poor correlation was due to multiple precipitation events over the test area during the experiment period, which caused high variations in the soil moisture values for that surface layer.

1.4 Remaining Challenges

Previous research has not undertaken direct comparison of all three non-invasive technologies, nor has the effect of varying pipe depths on the detectability of the water leaks been tested for any of the non-invasive technologies. This paper assesses both by testing the capabilities of the three non-invasive technologies against three varying pipe depths and comparing the results.

The majority of the GPR experiments reviewed were carried out within a controlled laboratory environment and tested on smaller pipe sizes not consistent with typical trunk infrastructure. It is possible to criticise the previous work for failing to use larger pipe sizes. The scope of this paper, however, does not permit this gap to be filled and restricts the experiment to pipe sizes consistent with previous research in order to allow a like-for-like comparison. The experiment presented in this paper was established outside of a controlled laboratory environment within the soil found on the chosen test site.

Previous studies (Atef et al., 2016; Khader, 2016; Hawari et al., 2017) have identified the optimal flying heights and speed for the use of thermal infrared cameras in leak detection, yet these flying heights (2 m above ground level) are not feasible in an urban environment due to obstructions such as trees and buildings. This paper investigates if a flying height higher than that determined as optimal is still capable of identifying the underground water leaks.

The modified TVDI developed by Chen et al. (2011) has not been directly applied to the application of underground water pipe leak detection, yet the purpose of the index as a means of reporting on soil moisture or soil dryness could be applied as the index is generated from surface temperature, which will be affected by the presence of excess water due to the underground pipe leaks. It is theorised then that identified leak locations will have low TVDI values due to the presence of water from the underground leaks.

2 METHODOLOGY

This section outlines the non-invasive technologies employed, the test site chosen and the experimental setup, field processes and data processes used, and the data analysis undertaken to obtain the results.

2.1 Equipment

2.1.1 Ground Penetrating Radar

The Leica DS2000 ground penetrating radar has a dual-frequency antenna that emits signals on the 250 MHz and 700 MHz frequencies, allowing for low-resolution deep scans and high-resolution shallow scans simultaneously. It has a scan interval of 42 scans per metre of travel and when set to a sample rate of 512 will perform 381 scans per second per channel, of which the unit has two (Leica Geosystems, 2023). The GPR unit is set up and controlled by the uNext software, which shows live 2D radargrams of the deep and shallow channels (250 MHz and 700 MHz, respectively) as the unit travels forwards or backwards and saves the scans for post-processing.

2.1.2 Infrared Thermal Imagery

The DJI Mavic 2 Enterprise Advanced drone is equipped with a dual camera system, allowing simultaneous capture of visible and infrared thermal images. The thermal camera is capable of capturing images in the 8-14 μm spectral band range with a sensor resolution of 160 x 120 pixels (DJI, 2023a).

2.1.3 Multispectral Imagery

The DJI P4 Multispectral drone has six 1/2.9” CMOS sensors, one RGB for visible light images and five monochrome sensors for multispectral imaging. It is equipped with the following filters capturing the different spectral bands (DJI, 2023b):

- Blue (B): 450 nm ± 16 nm
- Green (G): 560 nm ± 16 nm
- Red (R): 650 nm ± 16 nm
- Red Edge (RE): 730 nm ± 16 nm
- Near-infrared (NIR): 840 nm ± 26 nm

The P4 Multispectral drone has an integrated spectral sunlight sensor, capturing solar irradiance at the same time as image capture, allowing for more accurate post-processed data.

2.2 Experimental Site Location and Setup

The experimental site was located in the suburb of Camp Mountain, about 30 minutes west of the Brisbane CBD in south-east Queensland, Australia. It is a private property that covers 22,500 m^2, is generally flat and covered in grass with shrubs and medium to large trees. The predominant vegetation cover is short grass with small shrubs adjoining the area to the east and medium sized trees to the west. The experiment was conducted over an 11-day period at the end of July and start of August 2022. Typical weather for this time of year in the region is cool to mild, with dry days, cold nights and low levels of precipitation.

Three Ø 25 mm poly pipes were installed at depths of 0.2 m, 0.3 m and 0.45 m and a series of leaks simulated at different positions on each pipe. Figure 2 shows an overview of the experimental setup. Each pipe consisted of three simulated leaks and a control section at each end, which was left intact to assess the possibility of false positives. Each leak location and control section was then located by survey on the site datum to allow for leak identification processes to be performed in relation to the leak locations. The pipes were then buried, ensuring the soil was compacted back into the trenches with no voids within the soil present. The experimental rig was then connected to a 20,000 L water tank, which gravity-fed water into the system.

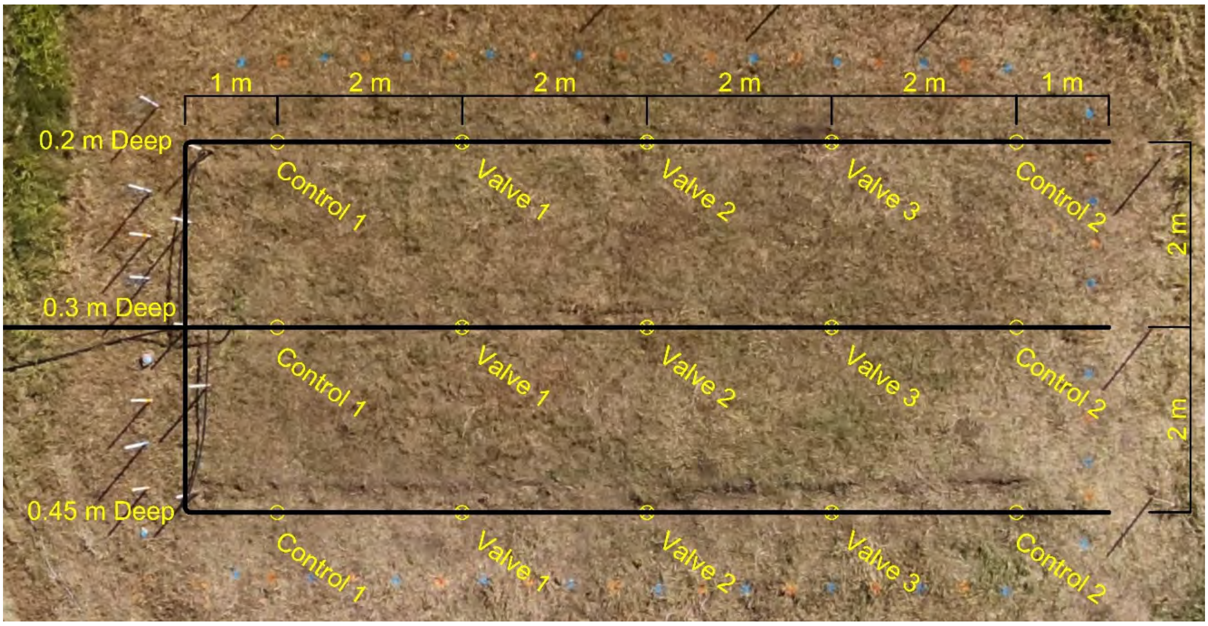

Figure 2: Overview of the experimental setup, showing the three pipes at varying depths and the locations of simulated leaks and control areas.

The valves used to simulate the leaks were set at a flow rate of approximately 2.0 L/hr, resulting in approximately 18.0 L of water leaked into the surrounding soil every hour. Scans with the GPR and images captured with the drones were then performed post start of the leak at 1 hour, 2 hours, 24 hours, 48 hours, 4 days, 7 days and finally 11 days. It is estimated that approximately 4,750 L was leaked into the surrounding soil during the 11-day testing period.

2.3 Field Processes

This section outlines the steps undertaken for each non-invasive technology to obtain the data for leak identification.

2.3.1 Ground Penetrating Radar

An equally spaced grid of 0.5 m aligned to each pipe and leak location was established over the buried pipes. The grid consisted of 19 scans performed perpendicular to the buried pipes and 11 scans parallel to the pipes. Perpendicular grids were aligned with the simulated leaks and the parallel grids to the buried pipes. Grids at either end of the pipes were chosen as the control sections where no leak was present.

The odometer of the GPR unit was calibrated over a known length prior to beginning the experiment and the self-calibration that is performed at the beginning of each set of scans conducted away from the buried pipes in the same location for each set of scans. A steady, consistent pace was then used to perform each scan.

2.3.2 Infrared Thermal Imagery

Ground Control Points (GCPs) were established around the experiment site on the site datum. For GCPs to be visible in thermal imagery, the target should have a differing emissivity value compared to the surrounding surfaces (Boesch, 2017). The experiment site was predominately grass and exposed soil, which have emissivity values of between 0.96-0.98 ε and 0.90-0.98 ε respectively (An et al., 2017). Aluminium foil was utilised on the GCPs, which has a low emissivity value. When paired with the dark carpet tile, the checkerboard pattern employed was also visible in the multispectral images.

Previous studies determined that flying heights between 1-2 m above ground level are optimal depending on certain factors (Atef et al., 2016; Khader, 2016; Hawari et al., 2017). However, this flying height is not feasible in most urban environments due to obstructions from structures such as buildings and trees. A flying height of 20 m was employed to assess if leak identification was still possible at higher flying heights.

The drone was manually positioned above the experiment site and overall images of the experiment site captured. Images were captured at mid-morning when the site was in full sunlight. Environmental site conditions such as ambient temperature, pressure and humidity were recorded at the time of flight for radiometric corrections performed in the post-processing software (Leblanc et al., 2021).

A section of the experiment site away from the buried pipes was saturated prior to flights being undertaken as a control area to determine the surface temperature values to be used in the leak identification process.

2.3.3 Temperature-Vegetation Dryness Index

The GCPs established for the thermal IR images were also utilised for the multispectral images taken to allow for image alignment during the data processing stage. The drone was manually positioned above the experiment site at a flying height of approximately 20 m and images captured of the entire site. The images were captured at mid-morning after capturing the IR thermal images. All six bands were captured but only the red and near-infrared bands were utilised in the data processing stage.

2.4 Data Processing

This section outlines the processing steps involved for each non-invasive technology to facilitate leak identification from the field data obtained.

2.4.1 Ground Penetrating Radar

The scan data was uploaded and processed in Geolitix, a cloud-based processing software. By performing the scans in a grid pattern, each scan can be positioned by inputting the project settings and profile parameters. For this project, equally spaced traces with a trace separation of 0.029 m and profile separations of 0.5 m were used. Since the deepest pipe depth was 0.45 m, the 700 MHz frequency was utilised because this allowed for higher resolution scans at the shallower depths.

The scan data was then cleaned by applying a time zero correction, an energy decay gain and a dewow and background subtraction filter. This step is vital in the leak identification process as the scan data is virtually unreadable without, as can be seen in Figure 3. Hyperbola fitting on a section of the pipe where no leak was present was then used to determine the signal velocity and dielectric constant of the soil.

The signal emitted from the GPR unit is shaped like a cone which spans a greater area as the signal travels deeper and is therefore projected out in front of the unit as it traverses forward. The signal is then reflected from the side of the pipe as the unit approaches with the shortest travel time (pipe depth) seen when the unit is located directly above the buried pipe and is then reflected off the side of the pipe again as the unit travels past the pipe, resulting in a hyperbola being formed (Utsi, 2017).

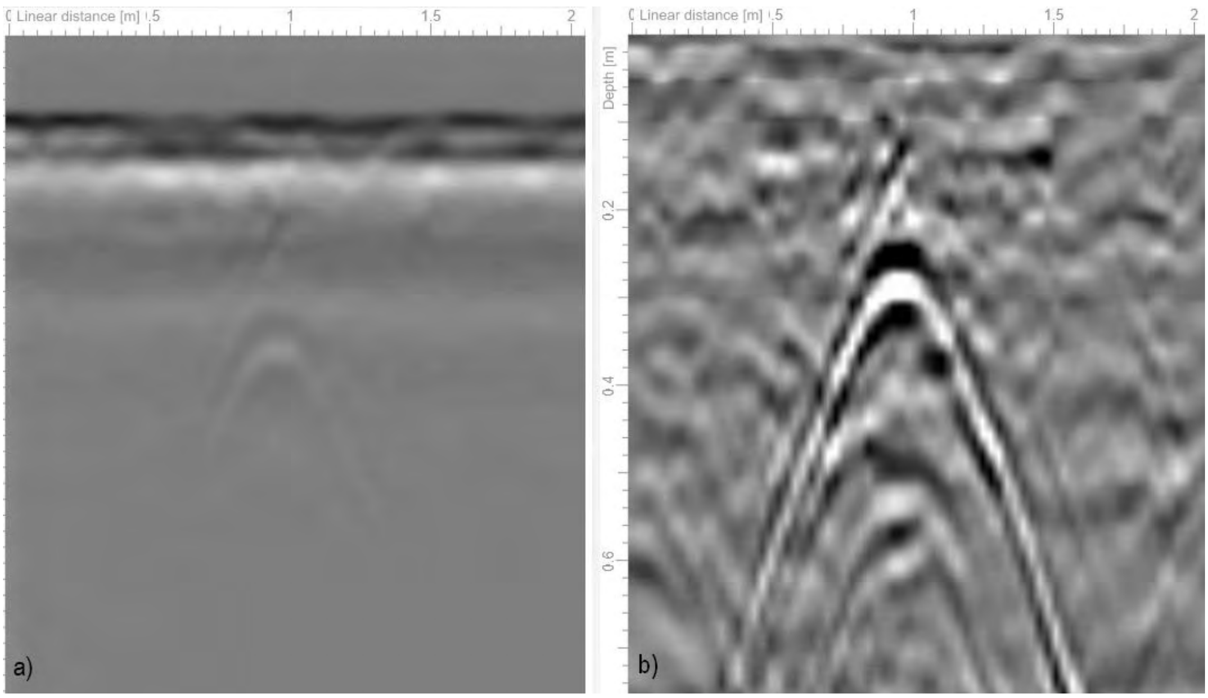

Figure 3: Scan data from the 1-hour post leak session (a) without the time zero correction, energy decay gain and dewow and background subtraction filters, and (b) with the correction, gain and filters applied. The hyperbola formed by the pipe can be clearly seen in the cleaned scan data.

The pipe depths were interpretated from the perpendicular scans by picking the apex of the hyperbola created from the buried pipe (see Figure 3b). For the longitudinal scans performed directly along the pipes, the pipe depth was determined via the automatic horizon algorithm within the software. If no definitive hyperbola was identifiable, then no interpretations were created for that scan at that pipe depth. The interpretations were exported to a spreadsheet with interpreted pipe depths plotted against travel distance.

The actual pipe depth and leak locations were plotted against the interpreted data. Leak identification was determined as an increase in pipe depth of 50 mm or more, that being twice the size of the pipe diameter, within the vicinity of the known leak locations. This identification was a combination of the perpendicular and longitudinal interpretations. Figure 4 shows the graph generated from the scan data for the 48 hours post leak session.

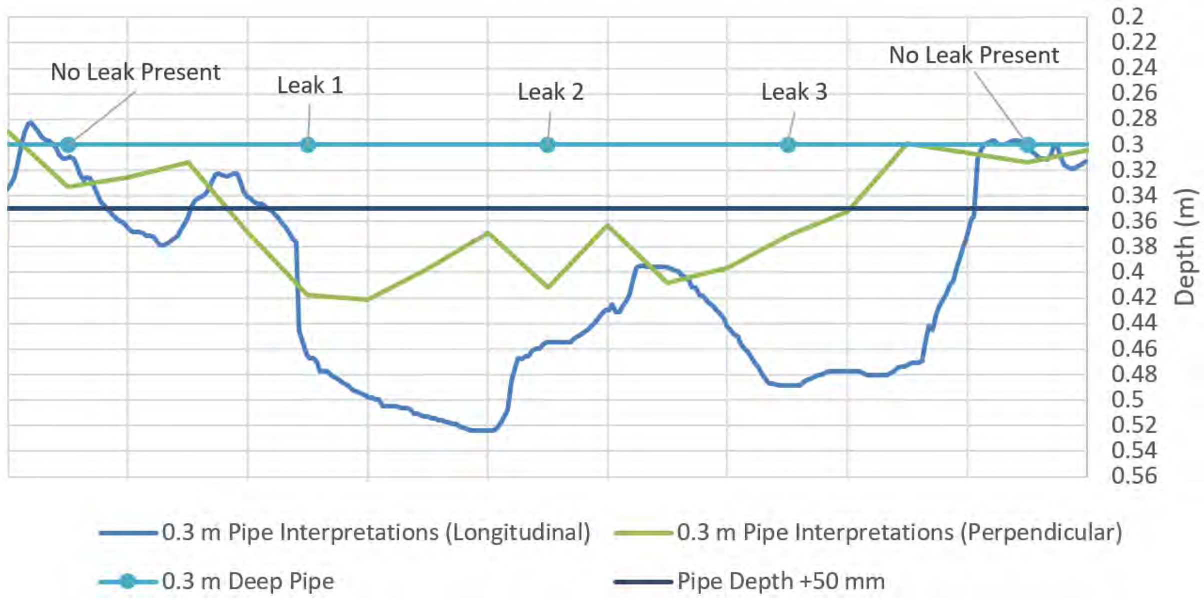

Figure 4: Interpretated pipe depths from the GPR scan data and the actual pipe with leak locations for the 0.3 m deep pipe after 48 hours. The increase in pipe depths at the leak locations can be seen due to the increase in soil moisture, decreasing the emitted wave velocity, resulting in a deeper than expected pipe.

2.4.2 Infrared Thermal Imagery

Images taken by the Mavic 2 Enterprise Advanced thermal camera, if not analysed within the native DJI software, do not contain any radiometric data for analysis within third-party programs. ThermoConverter by Aetha was used to convert the raw images to a RJPEG file format with the radiometric data attached to each pixel within the image. The converted images were then imported into FLIR Tools, which allows for different surface temperature analyses to be performed (e.g. spot, line, polygon) and the application of highlighting areas based on thresholds.

The thermal images were captured during the mid-morning before the experiment site had been exposed to the sunlight all day, which resulted in potential leak sites, i.e. areas that experienced visible wetness within the soil, having surface temperatures lower than that of the surrounding areas. The average temperature and standard deviation for the experiment site were determined for each image from the radiometric values and thresholds set at between one standard deviation and three standard deviations below the average temperature, with those areas between the thresholds being highlighted. The images were then georeferenced over the experiment site and

1 m^2 identification boxes established over the known leak sites to facilitate leak identification. Each identification box was analysed, and if substantial areas of highlighting were present within the identification box, it was deemed that a leak had been identified.

2.4.3 Temperature-Vegetation Dryness Index

To generate the TVDI images, the thermal IR (used for surface temperature value T_m) and near-infrared (NIR) images were warped onto the red image pixel grid using a first-degree polynomial and nearest neighbour mapping algorithm. Once aligned, the NDVI vs. T_m scatterplots were generated, and lines of best fit determined visually for the dry and wet edges of the scatterplot. Figure 5 shows the generated scatter plot for the images captured on day 11 after the leaks were started.

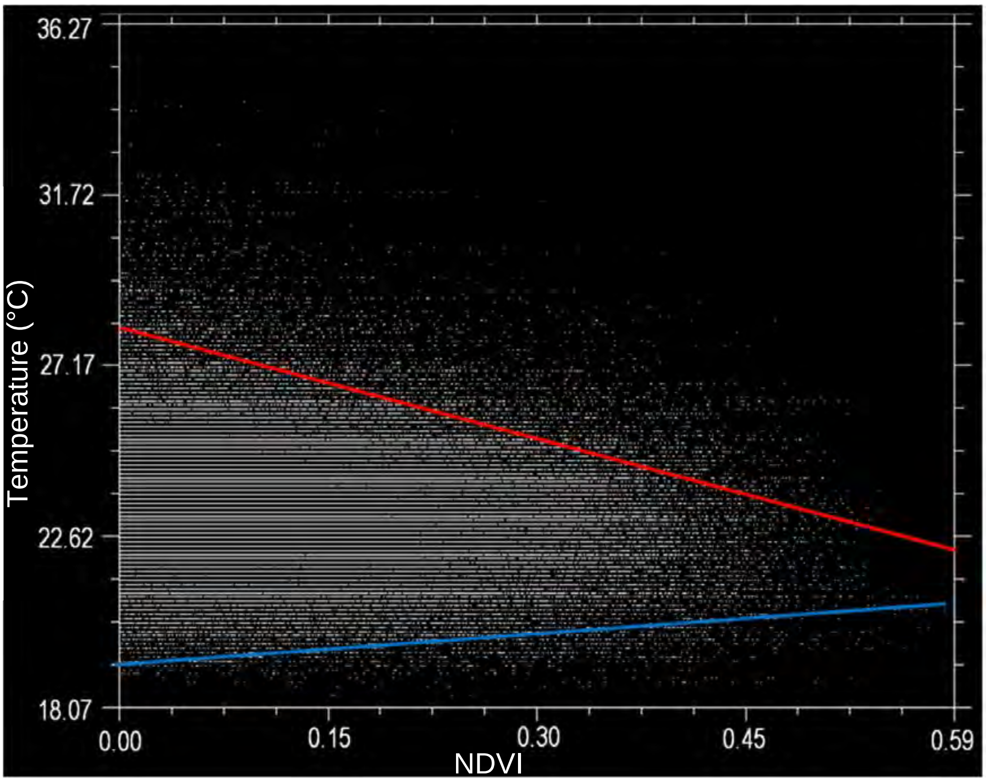

Figure 5: NDVI vs. measured surface temperature T_m scatterplot generated for the 11 days post leak session. The red line represents the dry edge and the blue line the wet edge. The parameters derived from each line are then used in Equation 1 to determine TVDI values.

The TVDI values were then calculated as follows (Sandholt et al., 2002):

$$TVDI = \frac{T_m - (a_w + b_w(NDVI))}{\left(a_d + b_d(NDVI)\right) - (a_w + b_w(NDVI))} \tag{1}$$

where T_m is measured surface temperature, a_d and a_w are the y-intercepts for the dry and wet edges and b_d and b_w are the slopes for the dry and wet edges, respectively.

The TVDI values for each pixel in the composite images were then calculated using the Raster Calculator in QGIS and images generated based on the TVDI pixel values. Finally, the images were assessed with the areas of low TVDI considered as potential leak sites.

2.5 Data Analysis

Confusion matrices were developed for each pipe depth and non-invasive technology for each session to determine the capabilities of each technology. A confusion matrix assesses each instance against one of four possible outcomes: true positive (TP), where a leak was present and accurately identified, false positive (FP), where a leak was not present but identified, true negative (TN), where no leak was present and none was identified, and false negative (FN), where a leak was present but not identified.

From the confusion matrix, the recall, accuracy and precision were calculated as follows to assess each technology's ability to accurately identify the leaks (Narkhede, 2018). F1-scores were then computed to compare the different pipe depths and non-invasive technologies (high F1-scores indicate better detection rates):

$$Recall = \frac{TP}{TP+FN} \tag{2}$$

$$Accuracy = \frac{TP+TN}{TP+FP+TN+FN} \tag{3}$$

$$Precision = \frac{TP}{TP+FP} \tag{4}$$

$$F1 - Score = \frac{2 * Recall * Precision}{Recall+Precision} \tag{5}$$

3 RESULTS AND DISCUSSION

3.1 Ground Penetrating Radar

The graphs generated from the GPR scan data interpretations consistently showed increases in the pipe depths where the simulated leaks were located, while the interpretated pipe depths were consistent with the actual pipe depths where no leak was present at either end of the pipe. Figure 1 shows a plot of the interpretated pipe depths for the perpendicular scans for the 0.2 m deep pipe over the course of the experiment. The perpendicular scan interpretations were given precedence over the longitudinal interpretations since the perpendicular interpretations were easily identified when hyperbolas were clearly defined in the scan data. The longitudinal interpretations were based on the in-built horizon fitting algorithm within Geolitix, and while the horizon was clearly identifiable in some instances (Figure 2), it was not as conclusive as the results from the perpendicular scans.

Similar results were obtained for the 0.3 m and 0.45 m deep pipes, with the interpretated pipe depths deeper than that of the actual pipe when in the vicinity of the simulated leaks. This phenomenon is seen due to the increase in soil moisture from the water leaks altering the dielectric constant of the surrounding soils. This in turn causes the emitted signal from the GPR unit to travel slower through the medium than expected, resulting in deeper interpretations for the pipe. This result is consistent with the findings of Cataldo et al. (2014) and Aslam et al. (2022).

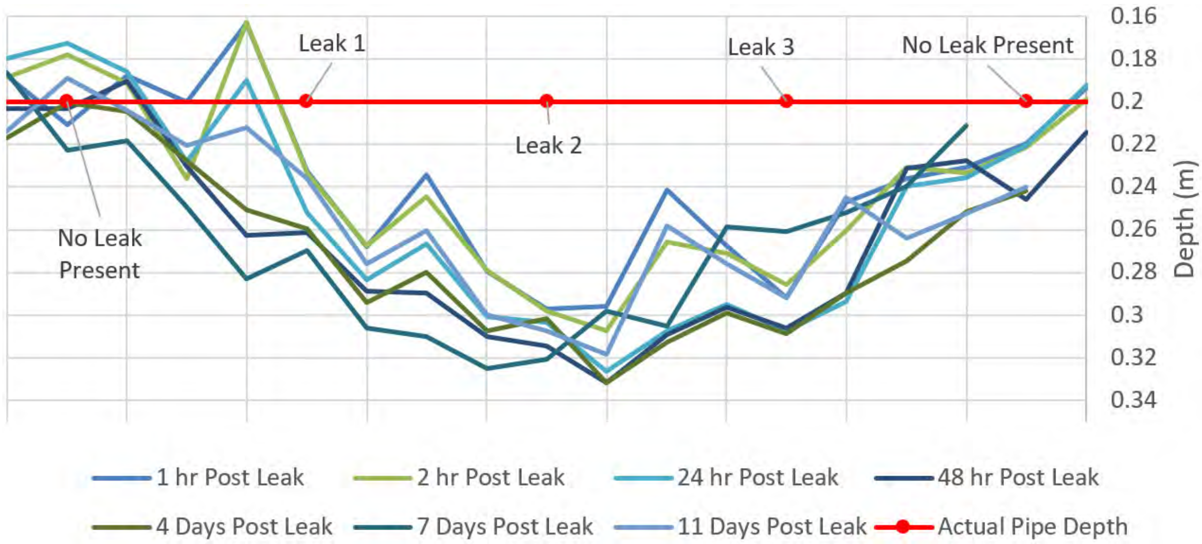

Figure 1: Combined pipe interpretations from the perpendicular scans for the 0.2 m deep pipe. The actual pipe depth and leak locations are indicated by the red line.

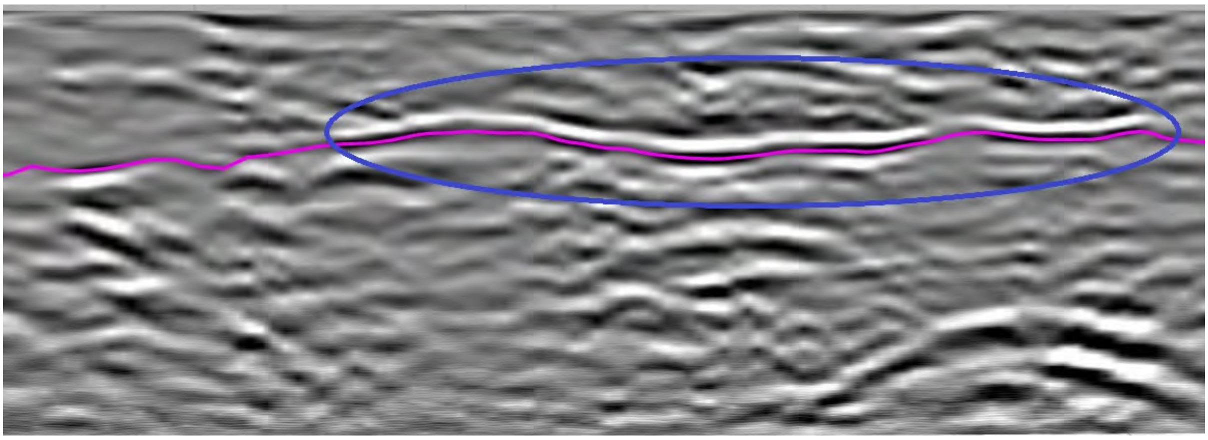

Figure 2: Pipe horizon interpretation from the longitudinal scan above the 0.3 m deep pipe during the 2 hours post leak session. The pink line represents the interpretated horizon. The blue ellipse indicates the section of pipe that has been clearly identified in the scan and which was used in determining the interpretated horizon.

As shown in Figure 1, while the interpretated pipe depths either side of the simulated leaks were higher than that of the location of the leaks in most cases, they were still not consistent with the actual pipe depths. This may be attributed to the water permeating horizontally through the trench between the leak locations due to the soil having been recently disturbed as well as vertically, causing a similar yet smaller alteration of the soil's dielectric constant to that observed at the leak locations. This indicates that the area affected by the leaks could be up to 4 m^2 (2 m by 2 m) surrounding the leak location. Further research with leaks spaced further apart may confirm the extent of the area of influence from the leaks.

Figure 3 shows the F1-scores for the GPR unit for each pipe depth during the experimental period. The GPR unit had a 100% accuracy and precision rate for all pipe depths for the sessions from 2 hours to 4 days post leak. The 0.2 m deep pipe had the best detection rate with an average F1-score of 0.95, compared to 0.86 for the 0.3 m deep pipe and 0.87 for the 0.45 m deep pipe. A decrease in F1-scores is visible over the last two sessions, with the scans performed 11 days after starting the leak having some of the lowest F1-scores for the entire period. The experiment site experienced small amounts of precipitation on days 5 and 10, which may have caused the decrease in detection rates due to increased amounts of moisture within the soil across the entire site, not just localised to the leak sites.

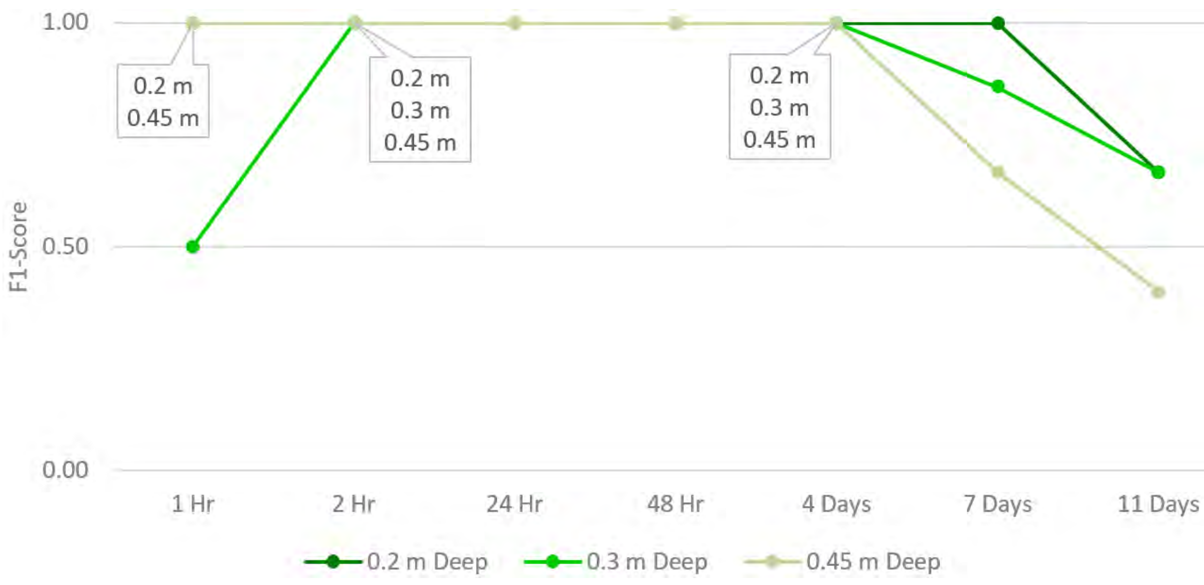

Figure 3: F1-scores for the GPR unit for each pipe depth in each session. The GPR was able to accurately identify the leaks with 100% accuracy and precision for the sessions between 2 hours and 4 days with a decrease in detection rates witnessed on the last day.

The 0.45 m deep pipe saw reductions in detection rates during the last two sessions with the 11 days post leak session receiving the lowest F1-score across all pipe depths for each session. The reduction in detection rates seen on day 11 may be attributed to the soil moisture content reaching a level that begins to deteriorate the emitted signal (Aslam et al., 2022). The deterioration of the emitted signal has more of a detrimental effect on the ability to detect the 0.45 m deep pipe in general as the signal is required to travel further than on the shallower pipe depths, resulting in lower detection rates.

A general rule of thumb when using GPR to detect pipes is that the maximum detectable depth for a pipe is between 5-10 times the pipe diameter (B. Keane, pers. comm.). Therefore, with the Ø 25 mm pipe, the maximum detectable depth is between 0.125 m and 0.25 m. This is not always the case as factors such as soil type, pipe material, antenna frequencies and signal scattering can affect the ability of the GPR unit in detecting underground pipes. Since the 0.45 m pipe was accurately identified in the scans for the first five sessions, the reduction in detection rates can be attributed to either the precipitation event or the soil moisture reaching a level that deteriorates the emitted signal due to the underground leaks. Further research employing larger pipes at greater depths would determine the maximum depth at which this non-invasive technology could detect the underground water pipe leaks.

The original experimental design was to continue testing the detection rates for a further 10 days (arriving at a total of 21 days) but was cut short due to the precipitation event. This extended period of testing, if the precipitation event had not occurred, would have determined if the leaks had caused the soil moisture to reach levels that began to deteriorate the emitted signal resulting in a reduction in leak detection rates. The precipitation event highlights a limitation in the use of this technology as the ability of the GPR to detect the leaks is dependent on the site having a certain level of 'dryness' to the soil, limiting the use to periods of no or low rainfall.

3.2 Infrared Thermal Images

During the experiment, visible wetness of the soil was observed on the 0.2 m deep pipe above valve 2. This area of wet soil was first observed during the 24 hour post leak session and was consistent throughout the experiment with signs of wet soil also observed above the other two leak locations on the 0.2 m deep pipe within 48 hours and the pipe trench eventually becoming entirely wet between the three leak locations and even spreading out past the trench to the sides by day 4.

Figure 4 shows the highlighted image generated from the 4 days post leak session. While the generated image has identified some areas as potential leak sites, the process has highlighted many other areas surrounding the test site where the grass was longer causing variations in the surface temperatures due to shading.

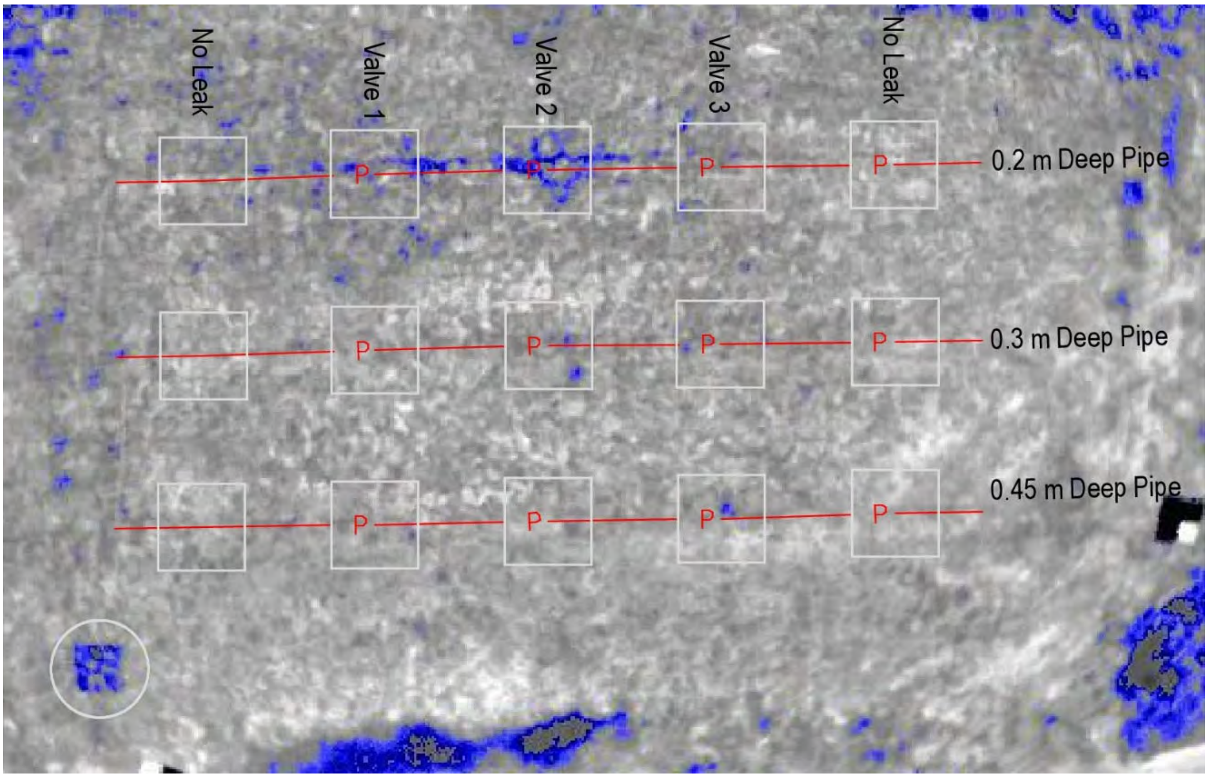

Figure 4: Highlighted infrared thermal image from the 4 days post leak session with the 1 m^2 identification boxes in white over the known leak locations. The areas of soil that were observed to be wet coincide with the highlighted areas over the 0.2 m deep pipe. The control wet section can also be seen in the bottom left of the image.

The images generated for the other sessions were consistent with that shown in Figure 4, with only the 0.2 m deep pipe leaks being consistently identified. Some instances of areas being highlighted as potential leak sites over the 0.3 m deep and 0.45 m deep pipe were observed in some images. However, no visible wetness of the soil was observed above either the 0.3 m or 0.45 m deep pipes. The principle, on which the leak detection with the IR thermal camera was based, was that the presence of water from the leak within the soil at the surface would increase or decrease the surface temperature. Since no visible wetness of the soil at the surface was witnessed, any leaks identified by the process above the 0.3 m and 0.45 m deep pipes could be attributed to variations in the surface materials, mainly that of bare soil, causing similar reductions in surface temperatures to those proposed to be caused by the leaks.

No leaks were identified during the 7 day post leak session for any of the pipe depths as the image was captured at the end of the day due to time-constraints as opposed to mid-morning. As an additional test, an increase in surface temperature instead of a decrease was used as threshold since the damp surface soil had experienced sun exposure all day and it was theorised that the surface temperatures would therefore be higher than the surrounding dry soil. No leaks were identified even though visible wetness above the 0.2 m deep pipe was observed on site. One factor that could affect the results seen for this session is that the experiment site was in full shadow by this time of day, which may have caused any variations in surface temperatures due to sun exposure to have evened out by the time the image was captured.

Figure 5 shows the F1-scores for the IR thermal drone for each pipe depth. The figure indicates that pipe depth has a significant effect on the ability of the IR thermal drone in detecting the underground pipe leaks as only leaks on the 0.2 m deep pipe were consistently identified. An increase in detection rates for all pipe depths was observed on the 11 days post leak session, which was attributed to the precipitation event experienced on site the previous day. The precipitation event increased the surface soil moisture on site, creating a similar effect to the surface temperatures as that experienced for the 0.2 m deep pipe due to the simulated leaks during the other sessions.

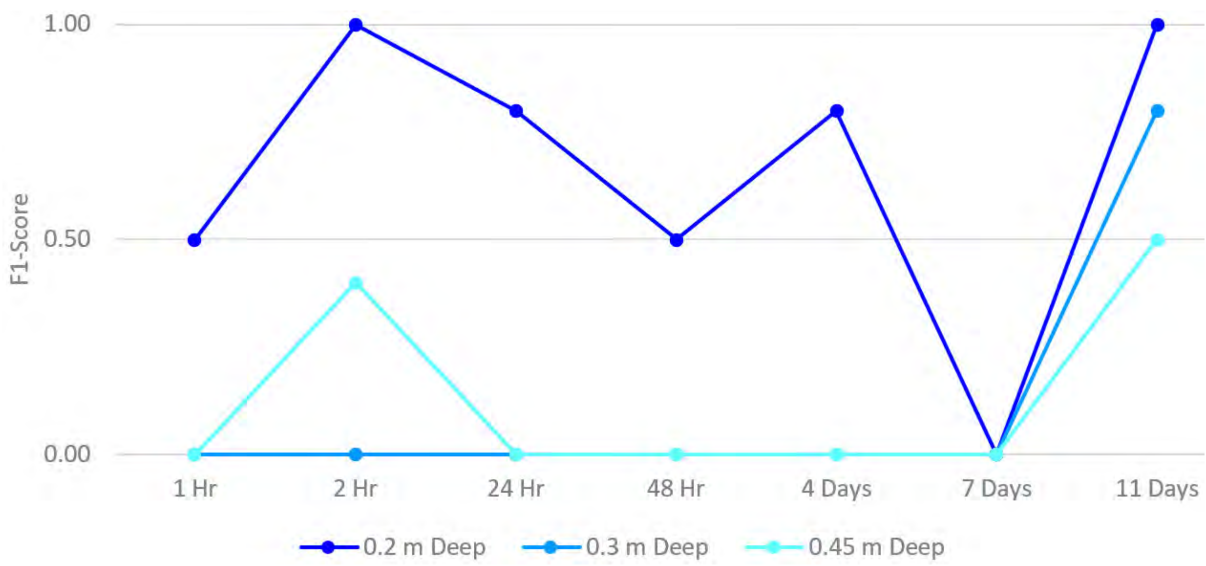

Figure 5: F1-scores for the IR thermal drone for each pipe depth in each session. The thermal images were only able to confidently identify leaks above the 0.2 m deep pipe due to the presence of visible dampness to the soil being observed. The increase in detection rates for all pipe depths on the last day were attributed to the precipitation event observed on site the day before.

A limitation in the use of this technology is that the time of day and year can affect the surrounding environmental conditions which affect the surface. The consequence of these factors is that no difference in surface temperature may be present, resulting in leak identification not being possible. The longer, unkempt grass surrounding the site and causing shading highlights a further limitation. Not all water pipelines are under well maintained areas, with many found under bitumen roads and concrete pathways instead of vegetated areas where this non-invasive technology and process would not be possible to employ for leak detection.

3.3 Temperature-Vegetation Dryness Index

The TVDI images generated were inconclusive and did not indicate any evidence of underground leaks. This inability to identify the leaks is attributed to the variations in surface materials, being low grass or bare soil in this case, and the different optical properties these covers have, which was identified by Krapez et al. (2022) as the main cause of false alarms.

Figure 6 shows the generated TVDI image for the 11 days post leak session. The figure shows areas with low TVDI values above the 0.2 m deep pipe as well as some sections of the 0.3 m deep pipe. The control wet section can be seen clearly within the blue circle. The areas of low TVDI values are consistent with those areas where visible dampness of the soil was observed, which were highlighted in the thermal IR images, indicating that the surface temperature component of the equation is the determining factor in leak identification with this non-invasive technology.

Since the IR thermal image was used for the surface temperature component of Equation 1, and an increase in detection rates was observed for this session with the IR thermal images due to the precipitation event on the previous day, these results may be biased by that precipitation event. Potentially, for TVDI to accurately identify underground water leaks, a certain level of soil moisture is required. In this case, the precipitation event that occurred on the previous day appears to have provided this required increase, allowing for the leaks to be identified. However, this hypothesis will need to be tested with further works.

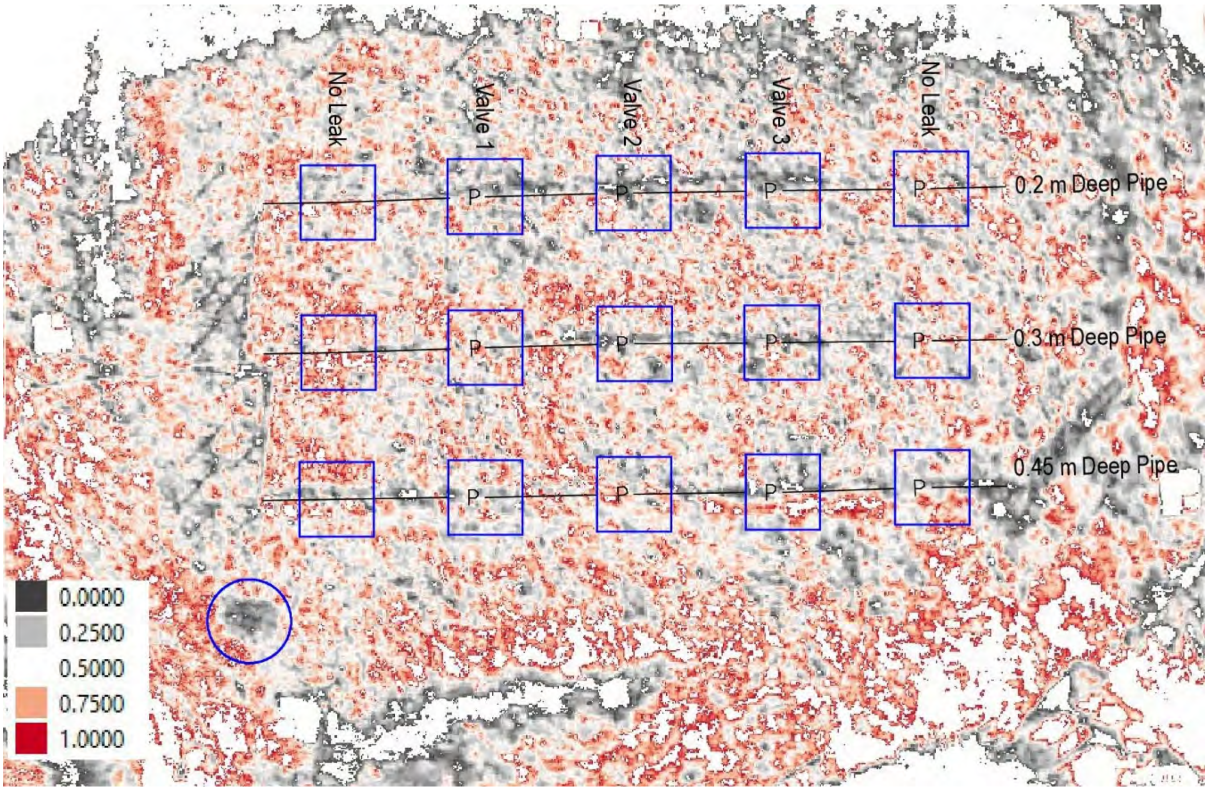

Figure 6: TVDI image generated for the 11 days post leak session. The light/dark grey areas indicate low TVDI values, being the areas with higher soil moisture. The area within the blue circle indicates the control wet section. Lower TVDI valves above the 0.2 m deep pipe can be seen, which closely aligned with those areas highlighted in the thermal IR image.

The inability of the generated TVDI images to identify leaks may be attributed to the image's bandwidth captured by the drones being too broad. The thermal image band width on the Mavic 2 Enterprise Advanced drone is 6 µm. The P4 Multispectral drone red bandwidth is 32 nm and the NIR bandwidth is 52 nm. It can be assumed that a finer bandwidth, which is not achievable with the drones used, may be required for TVDI to identify the underground leaks. Further research into bandwidths and TVDI's response in those bands could fill this knowledge gap identified by this project.

Due to time constraints in the project, longer time periods were unable to be tested where it was theorised that the presence of the underground water leaks may influence the growth of the surrounding vegetation, as shown by Huang et al. (2010) and Agapiou et al. (2016), affecting the NDVI values used within Equation 1 and resulting in better detection rates.

3.4 Pipe Depth

The 0.2 m deep pipe had the highest detection rates of all three pipe depths with an average F1-score of 0.8 when the F1-scores for both non-invasive technologies were combined over the entire testing period. Figure 7 shows the average F1-scores for each pipe depth for each session during the testing period. It is evident that the 0.2 m deep pipe had the highest detection rates for every session while the 0.3 m and 0.45 m deep pipes both had similar detection rates. This indicates that pipe depth is a significant factor in leak identification regardless of the non-invasive technology employed.

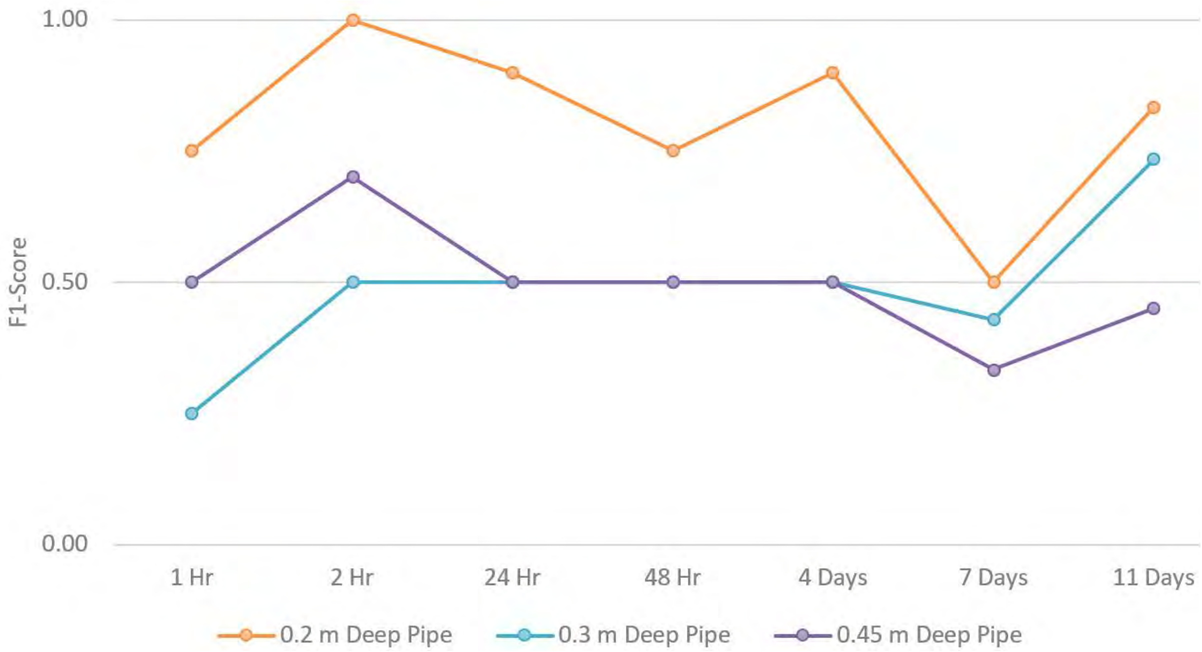

Figure 7: Average F1-scores for each pipe depth from a combination of both non-invasive technologies. The 0.2 m deep pipe had the highest detection rates for every session with the other two pipe depths having similar detection rates.

3.5 Overall Results

Table 1 shows the percentages for the correctly identified (true positive and true negative) and falsely identified (false positive and false negative) leaks for each technology over each pipe depth. The percentages were calculated from all seven sessions with each column having a sample size of 35 (21 simulated leaks and 14 control sections). It can be seen that the Ground Penetrating Radar was capable of accurately identifying the leaks on all three pipe depths at a rate of 86% for the 0.3 m and 0.45 m deep pipes and 94% for the 0.2 m deep pipe. Only the 0.2 m deep pipe for the infrared thermal images had an identification rate higher than 50% correctly identified, with a rate of 74%.

Table 1: Overall percentages of the correctly and falsely identified leaks for GPR and IR for each pipe depth. All three pipe depths with the GPR had higher correctly identified percenatge rates than that of the 0.2 m deep IR rate, which had the best detection rates for that technology.

		Leak Identification (Overall)	
Pipe Depth	**Non-Invasive Technology**	**Correct**	**Incorrect**
0.2 m	IR Thermal	74%	26%
	GPR	94%	6%
0.3 m	IR Thermal	46%	54%
	GPR	86%	14%
0.45 m	IR Thermal	43%	57%
	GPR	86%	14%

These figures further confirm that pipe depth is the driving factor in leak identification with thermal IR whereas GPR is suitable for all three pipe depths.

4 CONCLUDING REMARKS

In this paper, three non-invasive technologies were tested to determine the capabilities and limitations in the detection of underground water pipe leaks. Each technology was tested on simulated leaks present on three pipes at varying depths over a period of 11 days. The results obtained indicate that the GPR unit is the most efficient in leak detection due to the presence of water from the leaks altering the soil’s dielectric constant, resulting in the interpreted pipe depths from the scans appearing deeper than the actual pipe. This phenomenon was observed for each pipe depth and from as early as 1 hour after beginning the leaks. The ability of the IR thermal images to identify leaks was limited to those present on the 0.2 m deep pipe, indicating pipe depth to be a significant factor in leak detection with this non-invasive technology, while the TVDI images generated were inconclusive in identifying leaks.

This research has determined the capabilities and limitations of each non-invasive technology and has improved the understanding in employing these technologies in leak detection. Further research employing larger pipe sizes at greater depths with testing conducted over longer time periods will offer a deeper understanding of the potential of these non-invasive technologies in providing an efficient, low-cost option for identifying underground water pipe leaks.

ACKNOWLEDGEMENTS

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Sensor Networks for Monitoring Major Infrastructure and Pre-Emptive Activity to Avoid Catastrophic Failures

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ABSTRACT

The application of autonomous sensors to monitor major pieces of infrastructure has been well understood for over 15 years. During this time, sensors have become lower powered, easier to install and with more efficient data flows. This has democratised the act of monitoring across a wider range of end users, allowing more time-sensitive and data-supported decisions. This paper outlines the application of sensors in monitoring rail and tunnel infrastructure whilst also demonstrating instances where the use of sensors has led to actions preventing a potential catastrophic failure. In the rail sector, the use of biaxial (now triaxial) sensors to measure lateral trackbed deformation (cant) led to the correlation of longitudinal tilt with manually surveyed settlement. Tilt sensors are now widely deployed in the rail environment, negating the need for manual survey and the line-of-sight requirement for an optical measurement. The application of sensors can measure tunnel convergence, settlement or ovalisation. Similarly in tunnels, line of sight for traditional total station measurements can often be limited or ongoingly obstructed. A key feature of the use of sensors and cloud reporting is the configuration of thresholds and alerts to notify key personnel that an underlying structure is approaching non-conformance or, in some instances, failure. This paper demonstrates the data that led to key decisions being made to avert potential failures. The use of autonomous sensors has the potential to increase data collection, analysis and cost efficiencies whilst also keeping the workforce and community safe.

KEYWORDS: *Rail, tunnel, sensor, alert, failure*.

1 INTRODUCTION

Monitoring is a key activity primarily undertaken by surveyors and often requires interaction with other professions such as engineers and geotechnicians. Often, the success of a monitoring program is not simply reliant on the taking of measurement but also the ability to take this measurement repetitively and ensure results are distributed efficiently. As urban populations typically become denser, the interaction between social infrastructure and construction activities increasingly become unavoidable. Monitoring is inevitably mandated statutorily or, if not, undertaken by the constructor as a means of maintaining positive community relations.

This paper reflects on the application of sensor-based monitoring systems and shows not only the data leading up to a failure but how the effective application of a system has led to the avoidance of potentially damaging failures. It should be noted that the sensors discussed in this paper have been independently verified against conventional surveying and measuring techniques by the Monash Institute of Rail Technology (Muthuraj and Naidoo, 2021) and the

Transportation Technology Center Inc. (TTCI) in the United States (Wilk, 2021). In the interest of focusing this paper on applications, their results will not be discussed here.

2 MONITORING SYSTEMS

2.1 Definition

This paper refers to monitoring as being a system as opposed to the act of taking a measurement, albeit very precisely. A key element of a monitoring system is that the autonomous nature of monitoring produces results with high levels of precision with minimal human and instrument error. Not only is the act of taking a single measurement autonomous, but tasks such as taking confirmation measurements, increasing measurement frequency based on a threshold exceedance, transforming raw data and the emission of alerts should also be autonomous.

A sensor-based system relies on low-powered Micro-Electromechanical Sensors (MEMS) that utilise largely solid-state componentry to measure a variety of parameters including but not limited to tilt, displacement, temperature, current and vibration.

2.2 System Architecture

A sensor-based monitoring system will consist of a series of MEMS instruments classified as part of the ‘internet of things’ (IoT) category of equipment. These instruments are typically internally powered and communicate wirelessly to a central gateway via either direct communication or by meshing through adjacent sensors. From the gateway, data is transferred to the internet primarily over cellular networks or alternatively hardwired directly. All interactions with the sensors and data are undertaken over a web-based portal, although systems can be constructed on isolated, local networks if required.

3 APPLICATIONS

3.1 Rail

During the time of rail works, significant levels of disturbance may be imposed on the track area, with the imperative that public transport and private rail networks remain operating with a high degree of surety. As such, monitoring systems are required to ensure track geometry is preserved within certain tolerances and a near-real-time system is often specified.

Track disturbance monitoring specifications typically call for an optical method to be utilised (Transport for NSW, 2016). Factors including poor line of sight, availability of personnel, accuracy and safety often render the use of optical instrumentation, either by manual methods or Autonomous Total Stations (ATS), impractical. Sensor-based systems do not rely on system-wide line of sight and can be installed rapidly by non-specialists. A crew of three can install 200 sensors in around four hours, covering over 500 linear meters of track.

In the context of trackbed monitoring, there are generally three variables which must be kept within tolerance: track cant, track twist and track displacement in both the vertical (settlement) and horizontal (slew) directions (Figure 1).

Figure 1: Typical trackbed installation.

3.1.1 Cant and Twist

The cant on a railway track is the rate of change in elevation between the two rails. The tilt sensors will measure any change in angle of the sleeper. For this to work effectively, the sleeper must be mechanically rigid and firmly attached to the rail via the shoes and clips. The high-precision tilt sensors measure changes in the cant, as reflected by changes in the angle of the sleeper, which is recorded by the sensor and transmitted back via the gateway.

The sensor records an absolute reading of angle, relative to horizontal. There are of course many factors that can affect this, such as the mounting, the current tilt angle of the sleeper, thickness of adhesive and so on. The sensors are digitally baselined and subsequent readings are presented online relative to this baseline.

The change in displacement of one rail relative to the other is then computed as:

$$\delta = sin\alpha \cdot l \tag{1}$$

where δ is the vertical displacement of one rail relative to the other, α is the measured change in angle of the sleeper measured in the lateral direction (Y axis) and l is the track gauge.

3.1.2 Longitudinal Settlement

Settlement is calculated by using a virtual beam chain whereby the rail acts as a proxy for the actual beam (Figure 2). The start and end of the virtual beam chain should ideally be located outside the zone of influence. There is a qualification of the displacement at each location – if the displacement is out of an expected range, then it is assumed to be disturbed and not included in the cumulative calculation. Calibrations can be made between the actual settlement, if known, and the indicative settlement.

The vertical displacement at each chainage location can be computed as:

$$\Delta Z_n = L \cdot sin\ (\theta_n) \tag{2}$$

where ΔZ is the vertical displacement from one sensor to another, L is the sensor spacing and θ is the sleeper angle measured by the sensor in the longitudinal direction (X axis). The accumulated vertical displacement for each chainage location may then be expressed as:

$$accumulated\_\Delta Z_n = \sum_{i=0}^{n} \Delta Z_i \tag{3}$$

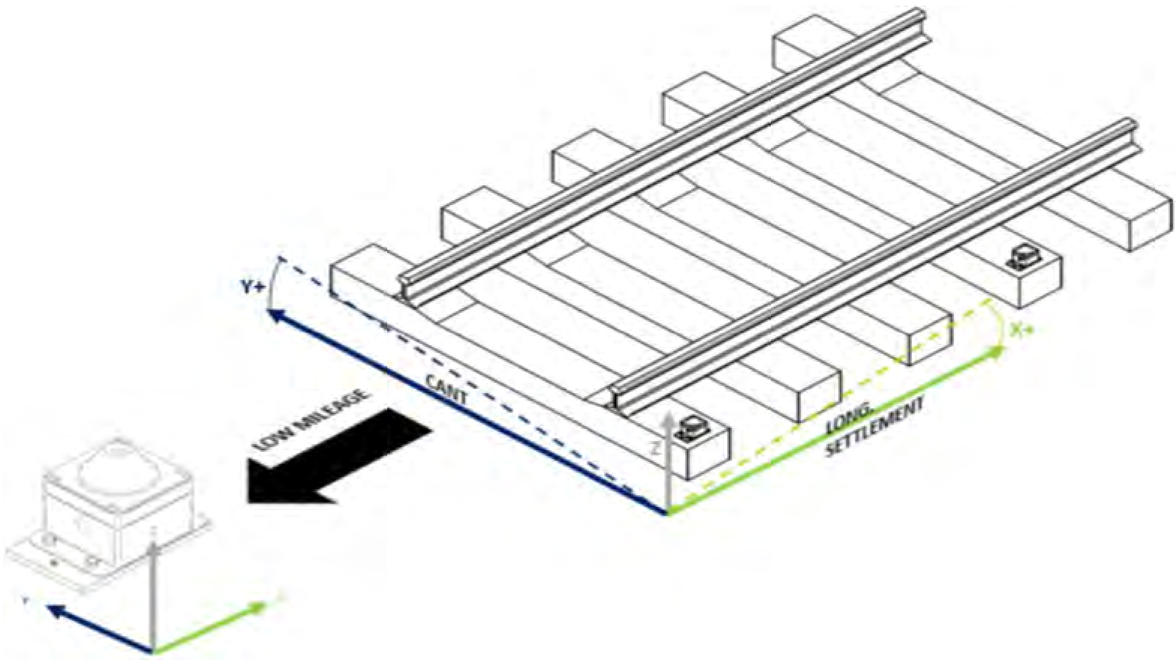

Figure 2: Sensor location and axes orientation.

3.1.3 Slew

An Optical Displacement Sensor (ODS) can be used to measure track slew, i.e. horizontal displacement (Figure 3). The node is installed past the track cess in a stable location and will point towards the rail web. No reflective target is required. The integrated tilt sensor will indicate sensor movement and the displacement must be disqualified until repositioned. Alternatively, the sensor can be track-mounted and measure out to a fixed object or to an adjacent track to measure relative slew. In this instance, as the sensor is tilt-integrated, the sensor will perform the previously described displacement measurements.

Figure 3: Stanchion-mounted sensors measuring track slew.

3.2 Tunnels

A common parameter in tunnel monitoring is convergence as observation of changes of the tunnel profile perpendicular to the alignment. This can be conducted as life cycle monitoring of ageing masonry tunnels as well as temporary observation of deformation induced by adjacent construction measures or even advance and construction of the tunnel itself (Rennen, 2022).

Autonomous monitoring systems are routinely deployed during the construction cycle to overcome disruptions to the tunnelling process and remove personnel from confined spaces. ATS systems have been a widely used monitoring method whereby the biggest share of investment is with the total station, and efficiencies are gained by monitoring multiple points from a single location. Drawbacks occur when the quality of observations decreases over distance with likely obstructions from dust, construction infrastructure or machinery. Furthermore, as distances increase, resolving targets with small relative incidence angles can become problematic. The ATS itself may also present as a ‘high-profile’ object within the tunnel, increasing the likelihood of damage.

3.2.1 ODS Monitoring

The ODS nodes include a 3-axes MEMS tilt sensor enabling observation of rotational movement at each location regardless of the node orientation, as well as measuring the distance to a reflective target (Figure 4). Achieving the nominal sub-millimetre accuracy not only depends on the environmental conditions, e.g. the medium the laser beam has to travel through, but also the quality and orientation of the target. Aiming at rough and/or oblique surfaces decreases accuracy as the incidence point might shift inadequately. Very short windows of installation can also be achieved with four sections of sensors in an hour being achievable (Rennen, 2022).

Figure 4: Installed ODS convergence monitoring system.

ODS data can be presented in either relative or absolute figures. Results can be presented in schematic format whereby the last reading is displayed or can be displayed in a graphical time series by individual sensor or in multiples of relevant sensors (Figure 5).

Figure 5: Section diagram of ODS convergence monitoring installation (Rennen, 2022).

3.2.2 Beam Chain Monitoring

An ODS array may not be practical, or the tunnel deformation may require a higher definition of data points to define the profile of a tunnel. In this instance, a sensor beam chain may be installed around the profile of the tunnel to provide a more granular monitoring profile. The application of low-profile sensors may reduce the risk of impinging a kinematic envelope (Figure 6).

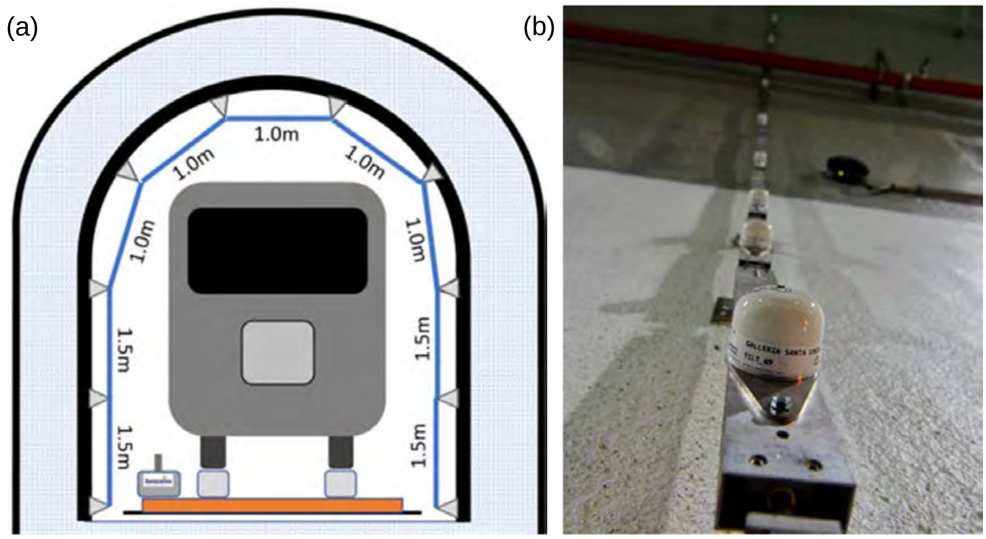

Figure 6: (a) Schematic sectional representation of a tilt beam monitoring installation (Rennen, 2022), and (b) low-profile sensors installed in a tunnel beam chain.

3.2.3 Virtual Beam Chain Monitoring

Particularly in tunnels generated by a Tunnel Boring Machine (TBM), the installation of a 360° physical beam chain may not be feasible. The deployment of low-profile tilt sensors in profile sections can be coupled with the application of virtual beam lengths. This length would represent each side of the virtual polygon created if lines were extended from each sensor. The sensor would be located at the mid-point of each side (Figure 7).

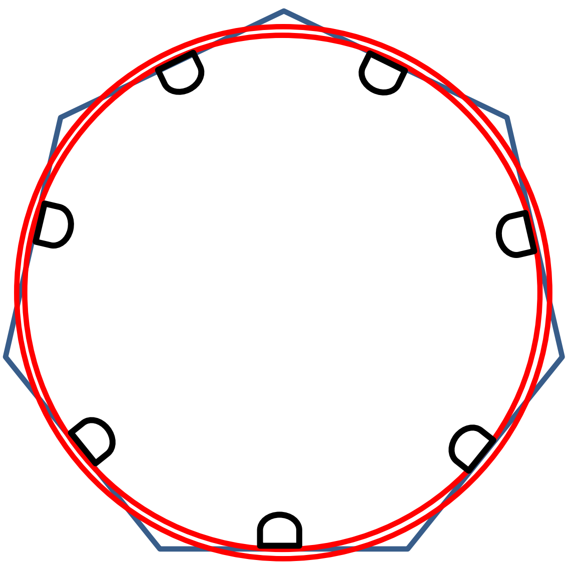

Figure 7: Section diagram of virtual beams (blue) within a TBM generated tunnel.

The virtual beams would be of a known length, based on the diameter of the tunnel. Tilt measurements generated by the sensors would show how the vertexes of the virtual polygon are deforming, and convergence calculations could be performed along the diagonals accordingly.

3.3 Slope Stability

Slope stability monitoring can cover applications for unconsolidated embankments through to road and rail cuttings. Geotechnical failures can impact infrastructure and can happen suddenly, particularly if located in areas susceptible to high rainfall or seismicity. Sensor systems producing numerical data can be enhanced with the addition of integrated cameras that can be triggered to take a photo if a sensor moves through predefined thresholds. Furthermore, these systems can autonomously increase their measurement frequency to provide confirmation readings or the rate of deformation (Figure 8).

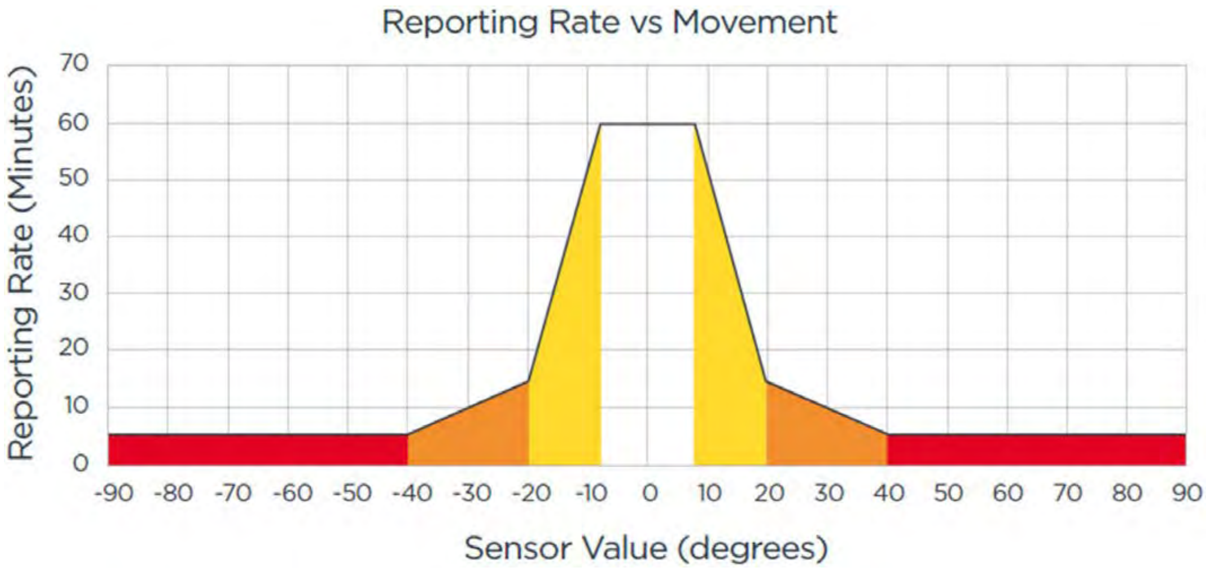

Figure 8: Charted representation of a user-defined autonomous monitoring regime (Senceive, 2022).

Sensor monitoring systems can provide rapid response times, even from dense sensor networks. Sensors are programmed to wake up from cyclic sampling when movement is detected, and the gateway will switch to low-latency reporting rates. Sensor networks can self-heal and recover in the event of individual nodes being damaged (Senceive, 2022).

3.4 Pre-Failure Scenarios

3.4.1 Brick Tower

A client had a system of low-profile sensors installed on a heritage-era brick tower. The 30-minute measurement intervals show the diurnal trend of movement that correlates with the temperature profile. The low temperatures in February represent a period of unseasonably high rainfall, which contributed to a shift in the underlying structure (Figure 9). Whilst the structure did not continue to deform, the risk of failure was deemed high enough to have the structure significantly remediated.

Figure 9: Online analysis package, showing sensor performance after low temperatures and high rainfall.

3.4.2 Rock Cutting

A monitoring system had been installed on a rock cutting since 2018. The system was configured to generate displacement data in millimetres by factoring in the measured tilt with the dimensions of each hazard the sensors were mounted on. The site went into a higher level of awareness when the first threshold was exceeded during March 2021, and alerts were sent accordingly (Figure 10). The hazard continued to deform for next the week until the higher threshold was exceeded, and alerts were sent to cease all activities in the area. At this point, the hazard was removed by a specialist team and made safe. The sensor was then redeployed in the same area.

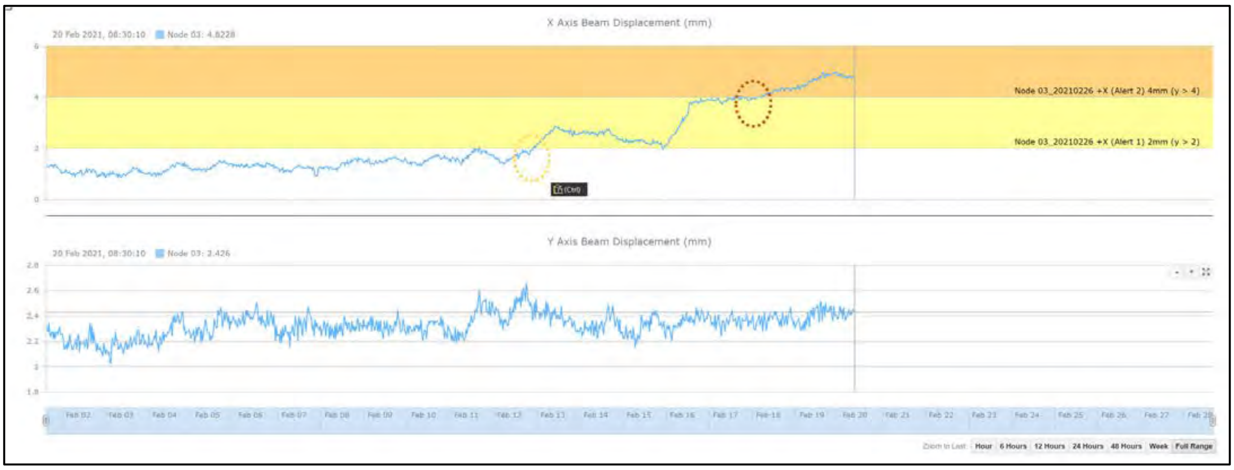

Figure 10: Online analysis package, showing sensor performance and threshold exceedances highlighted in orange and red.

3.4.3 Slope Failure

In contrast to the previous scenarios, remediation activities may not always be practical. In the instance of the slope failure shown in Figures 11 & 12, the sensors showed the deformation in the days leading up to the slope failure, allowing the correct procedures to be followed to ensure personnel and equipment could be made safe.

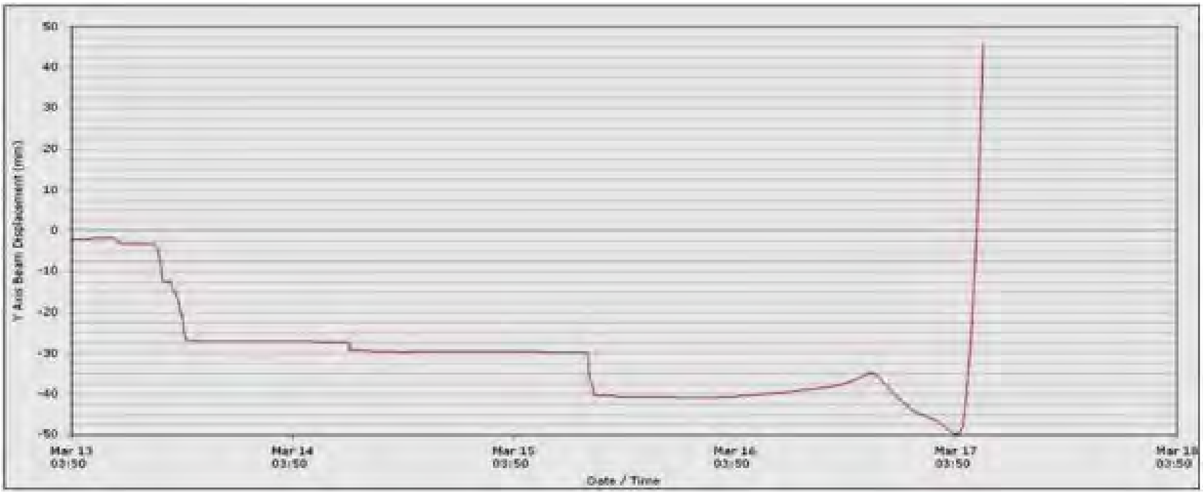

Figure 11: Online analysis package, showing the incremental deformation in the 5 days leading to the slope failure.

Figure 12: Monitoring system layout with outlined slope failure.

4 CONCLUDING REMARKS

This paper has demonstrated that sensor-based monitoring systems provide advantages over manual processes and, in some applications, autonomous total stations. These advantages are associated with increased productivity and safety, reduced size and space limitations. When a structure has exceeded a threshold, the autonomous monitoring system is able to efficiently leverage its own architecture to increase its observation rate, whilst a manual process requires duplication of effort. Furthermore, beyond monitoring the spatial characteristics of a structure, systems can be expanded to structural, geotechnical and environmental parameters within the same hardware ecosystem. This functionality also enhances productivity and stakeholder interaction. As with any system, applications need to be carefully assessed within the limitations of the hardware prior to implementation.

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Remake of the Surveying and Spatial Information Regulation: Progress Update

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ABSTRACT

The legislative processes of New South Wales require a review of each regulation every 5 years. This is governed by section 10 of the Subordinate Legislation Act 1989 and ensures that the requirements of each regulation remain up to date and future focused. The remake of the Surveying and Spatial Information Regulation 2017 was postponed during 2022 and is scheduled to be replaced on or before 1 September 2023. The review process has required a substantial amount of time and input from many sectors. An online survey was distributed to the industry in 2021, and there have been many presentations and industry consultation throughout the process. The Parliamentary Counsel's Office has used a modern approach to redraft the regulation that has re-structured and changed all section numbers of the old regulation. This paper provides an overview of the proposed changes that are intended to be made to the Surveying and Spatial Information Regulation for release in 2023.

KEYWORDS: *Regulation, legislation, surveying, standards.*

1 INTRODUCTION

Under the Subordinate Legislation Act 1989 (NSW Legislation, 2023a), all statutory rules, i.e. regulations, must be remade every 5 years to ensure they remain relevant to government, community and industry needs. The Surveying and Spatial Information Regulation 2017 (NSW Legislation, 2023b) was due for repeal on 1 September 2022. However, a 12-month extension has been granted. An online questionnaire was distributed to the industry in early 2021 for comment, and a workshop with industry associations and industry leaders to obtain additional feedback and comment was conducted in September 2021. This paper briefly provides an update of the issues, amendments and reforms that are proposed to ensure the surveying industry is enabled and capable to provide modern surveying services. The reforms and amendments outlined in this document are generally minor in nature and do not make significant changes to survey practice in New South Wales.

2 PROCESS

The review process began in March 2021 by outlining possible and probable changes to the regulation (Gardner, 2021), followed by a corresponding series of presentations to the surveying industry. An online questionnaire was conducted from March to May 2021 to obtain views, comments and suggestions for improvement from the surveying industry. The results were used to refine the final submission to the Parliamentary Counsel's Office to prepare the new draft regulation that will be circulated to all surveyors, users of surveying services, government agencies and relevant industry associations in a final draft exposure regulation. The remake of the regulation has been postponed 12 months until 1 September 2023, due to work commitments for new bills, reformatting styles and standards, and other reforms.

A Regulatory Impact Statement will accompany a draft exposure version of the proposed regulation this year to gain final industry, government and community comments in order to ensure that all alternatives, options, cost and benefits have been considered and determined for the final regulation.

3 SUMMARY OF PROPOSED CHANGES TO DATE

A summary of the proposed changes from the Surveying and Spatial Information Regulation 2017 to the proposed Surveying and Spatial Information Regulation 2023 is outlined in Table 1. The sequence of numbers in the table are based upon the proposed section numbers of the proposed regulation. The proposed regulation has been completely re-structured, and all 'clause' numbers will change to new 'section' numbers.

Table 1: Summary of proposed changes to the Surveying and Spatial Information Regulation 2017. If a cell is blank, either no change or very minor changes are proposed.

Proposed Regulation	Proposed Change	Reason for Change
	Part 1: Preliminary	
1 Name of Regulation		
2 Commencement		
3 Application of Regulation – The Act, s 4 & 5		
4 Mining surveys – the Act, s 36	Update reference to the current "Survey & Drafting Directions for Mine Surveyors 2020 (NSW-Mines)".	Updated references.
5 Definitions		
Accurate MGA orientation	Add "positional uncertainty of 0.1m or less" to the existing survey Class of "D" or better.	Enable more flexibility and correct definition when determining accurate MGA orientation.
Established survey mark	Means a survey mark as approved. (By Surveyor-General, in SGD.)	Enable more flexibility.
Recognised Professional Training Agreement	Remove definition.	Recognised Professional Training Agreement is not used by the industry.
Validation	Means an approved rigorous method that assesses an instrument or method of measurement against a verified instrument or approved network.	A holistic scientific rigorous test performed once a year. For instruments or methods that do not carry their certification.
Verification	Means an approved rigorous method that assesses an instrument against the National Measurement Standard or the State Primary Standard.	In terms of instrument testing, a scientific rigorous test against a reference standard for instruments that can carry their certification.

Proposed Regulation	Proposed Change	Reason for Change
6 Reference to high-water mark and tidal and non-tidal waters in previous survey plans		
7 Urban and rural land surveys		
8 Conduct of surveys – the Act, s 36		
Part 2: Equipment and methods – the Act, s 36(2)(a)		
9 Measurement methods	Greater use of SGDs to prescribe measurement methods.	Clearer instructions.
10 Verification of electronic distance measuring equipment	Standardise the use of the term "verification" and "verified". Verification is a rigorous annual assessment of the capabilities of the EDM. Verification to be stored by the surveyor. Verification to be supplied for an audit or investigation.	Clearer breakdown of process required to ensure accuracy of equipment.
11 Verification of metal tapes and bands	Steel bands have been replaced with an option to verify a metal tape every 2 years.	Clearer breakdown of process required to ensure accuracy of equipment.
12 Validation of measurement methods	Surveyor to validate all non-verified methods. Includes GNSS and remote surveying methods.	Clearer breakdown of process required to ensure accuracy of equipment.
Part 3: Accuracy and measurement – the Act, s 36(2)(a)		
13 Tolerance of angular measurements		
14 Checking angular measurements		
15 Tolerance of length measurements		
16 Checking length measurements	Surveyor to 'check' measurements. Independent checks. Use independent method to make check. GNSS not to check GNSS.	This is to clarify the requirement and be more rigorous.
17 Tolerance of relative positions		
18 Other tolerances		
19 Checking accuracy of measurements and calculations	Use the word "check". Combine the outcome for age of partial survey and terrain details of lot into single mm+ppm for each partial lot. Add mm+ppm to survey certificate.	Simplify the outcome and enable E-plan digital compliance.
20 Calculation of areas of land	Areas of land to be calculated using commercial software. Approved method – Surveyor-General's Directions.	Refer to the SGDs and commercial software as suitable methods of determining area of land. Any commercially available survey software.
21 Compliance with Standards and Practices for Control Surveys		

Proposed Regulation	Proposed Change	Reason for Change
Part 4: Datum lines - the Act, s 36(2)(a)		
22 Horizontal datum line and orientation	MGA for <u>all</u> surveys. No magnetic meridian as datum (unless compiled plan). 3 survey marks for <u>all</u> surveys. Use established SCIMS coordinates for all 3 marks <u>or</u> use an approved GNSS method for all 3 marks. All marks must be within 1500m of the site. Approved GNSS coordinates must have a PU of 0.1m or less.	Simplifies the datum requirements and makes all plans have the same requirements. 80% of surveyors (from Survey Monkey results) agree that all plans should be on MGA. 2.5% of plans of survey currently use a magnetic meridian (MM) orientation.
23 Vertical datum	"Confirm", not "verify" the results. Add that only good SCIMS marks can be used, the same as clause 12.	
Part 5: Boundaries – the Act, s 36(2)(a) and (b)		
24 Re-survey of boundaries	Ensure that the surveyor either forms a common boundary with the adjoining parcel or provides a report to justify the discrepancy between the location of the boundary.	A re-survey is to place the boundary in the same position as it was located prior. Thus, forming a common boundary if all the plans are in agreement, or justifying the location of the boundary with extra survey if there is a discrepancy in the plans.
25 Monuments of original survey missing		
26 Measurement of boundaries		
27 Finding existing corner peg and reference mark		
28 Difference between measured and recorded boundary lengths		
29 Confirming terminals where only part of land to be surveyed		
30 Survey where boundary includes crooked fence		
31 Stratum surveys		
32 Surveys for affecting interests	Clarifies that this clause applies to surveys for affecting interests that extend beyond the main surveyed or subdivided area.	Clarifies the application of the clause.
33 First surveys for redefinition or subdivision of certain land	First definition will require consent of adjoining owner.	Ensure correct boundary is defined.
34 Changes in non-tidal and tidal waters or other natural feature boundaries	If present waterline is different to adopted MHWM or bank, then both are shown. Was in clause 47.	Increases the integrity of cadastral plans.

Proposed Regulation	Proposed Change	Reason for Change
35 Density of permanent survey marks		
36 Connection to permanent survey marks	Simplify the requirements for placing PSMs. Reduce the number of PSM placed. Use 250m of road frontage as the basis for network propagation. Amend subclause 42(2) to be consistent with subclause 41(1). Connections are limited to 250m (urban) and 1000m (rural). All PSMs must be shown in a closed connection.	The current formula is based on the number of parcels and the lot size is reducing, hence there is oversupply of PSMs in some areas. The new methodology is based on the distance of road frontage. This ensures that only close PSMs are used and direct connections between PSMs are shown. PSMs are not more the 250m apart along the length of any road.
37 Differences between measured and recorded lengths		
38 Surveys for identification or re-marking	Title and/or report to indicate intent of survey. Update sections that apply. New survey certificate.	Better understanding of requirements.
39 Surveys not requiring strict accuracy	The “agreement” between the client & surveyor for the survey not requiring strict accuracy is to be in writing. Review & update the clauses that apply. Refer to “classifications” of survey rather than “Class” of survey. Plan to report the “agreed” accuracy. Update the survey certificate.	When a Clause 9 survey is undertaken, there is no documented agreement of what was to occur or to what accuracy. Class has a specific meaning in surveying. The survey plan must convey the accuracy agreed.
Part 6: Marking – the Act, s 36(2)(f)		
40 Forms and styles of survey marks		
41 Boundary marks		
42 Marking of natural feature boundaries		
43 Marking boundaries of Crown managed land		
44 Reference marks generally	A second reference mark (RM) must be placed at any corner referenced by a ‘Reference Tree’ (as described in Schedule 3) that is found, that does not already have a second reference mark for that corner. If a specific point is used as RM, then an additional RM must be placed in the road.	Enable the preservation of basic cadastral infrastructure. Enable preservation of survey marks to ensue integrity of cadastre.
45 Reference marks for boundaries	Urban survey that creates or redefines a boundary that intersects with a water boundary, place a RM for that intersection. Rural survey that creates or redefines a boundary that intersects with a water boundary, place a RM for that intersection. No 500m limit. Allow double referencing if existing RM is within 30m.	Intersections with roads and rivers are treated the same Intersections with roads and rivers are treated the same. Allow efficient use of survey marks.

Proposed Regulation	Proposed Change	Reason for Change
46 Reference marks for roads	Delete clause 31(3)(d), this will be dealt with elsewhere. Show connections across road intersections and where width varies.	Improve understanding of Reg. Connections across intersections & where variable enables the road to be crossed mathematically without assumptions.
47 Reference marks for affecting interests		
48 Permanent survey marks	New requirement to ensure there is a diversity of PSM types placed. ¼ of PSMs to be PMs.	In order to improve survey marks preservation and greater survey integrity, it is proposed that a variety of survey marks are placed.
49 Use of broad arrows		
	Part 7: Field notes	
50 Recording observations	Change tile of clause to “Method of recording angles & bearing”. All distances, coordinates and heights must be recorded in metres.	Simplify the requirement of the Reg.
51 Surveyor to make field notes	Field notes must include all measurement methods used. All dates in field notes must be correct.	Simplify the requirement of the Reg.
52 Surveyor to sign and date field notes		
53 Field notes for surveys carried out by the Surveyor-General or public authorities		
	Part 8: Survey plans – the Act, s 36(2)(b)	
54 Method of showing bearings and distances		
55 Requirements for survey plans	Use the correct name (if any) assigned by the Geographical Names Board for any water feature shown on the plan. For partial surveys, the misclose vector tolerance for each parcel in accordance with section 19(3) to be shown. A complete description of all land affected on the first sheet for any acquisition or road plan.	The correct names must be used on survey plans. This is particularly important for survey plans as they are often the point where change is proposed. The misclose vector tolerance for each lot of a partial survey (mm+ppm). To ensure to correct indexing and searching is applied, the current Lot/DP reference must be shown.
56 Recording datum line	MGA for <u>all</u> surveys. No magnetic meridian as datum (unless compiled plan). 3 survey marks for <u>all</u> surveys. Use established SCIMS coordinates for all 3 marks <u>or</u> use an approved GNSS method for all 3 marks. The datum line statement must be shown as approved. The datum must be shown adjacent to the North Point.	Simplifies the datum requirements and makes all plans have the same requirements. 80% of surveyors (from Survey Monkey results) agree that all plans should be on MGA. Datum line must be shown as approved to assist understanding of the survey. It is important to maintain consistent language: the confirmation line is confirming the orientation.

Proposed Regulation	Proposed Change	Reason for Change
	The orientation must be confirmed to a 3rd mark and shown on the plan. The orientation and datum marks must be shown in a single loop with sequential lines.	The orientation marks must be shown in a closed loop with direct connections.
57 Showing boundaries on survey plans	Use "●" obstructed boundary symbol at corners that cannot be marked and no need for exemption. Remove requirement for clearing and blazing of rural un-fenced boundaries. Use 3" x 2" pegs as line marks (rural). Complete dimensions to include bearings, distances & area. Every road created must be a complete parcel. Connections across intersections, terminals and at variable with. Include details of any improvements, retaining walls, slip rails, jetties, etc. near water boundary.	Where it is physically impossible to place a survey mark (when the boundary corner lies within the material of a structure that does not have an accessible surface), use ●. Avoid conflict with environmental legislation to prevent or limit clearing. Enable appropriate marking. Better compression of the plan and ensure complete and accurate lot/road dimensions. Ensure all interests are recorded on survey plan.
58 Showing road boundaries on survey plans		
59 Showing affecting interests on survey plans		
60 Showing landward boundaries on survey plans	Update reference to Crown Lands Management Act 2016.	Be consistent with other legislation.
61 Showing natural feature boundaries on survey plans		
62 Survey plan to show coordinate schedule	Due to changes in clause 12, surveyor can adopt MGA orientation from established survey marks or approved GNSS. If approved GNSS method, hz Positional Uncertainty (PU) must be $\leq$ 0.1m. If stratum survey only (limited in height and/or depth), hz PU $\leq$ 3m.	All survey plans adopt MGA and the surveyor has more flexibility as to what survey method is adopted. New PU requirement of marks surveyed accurately. New PU requirement for stratum survey.
63 Survey plan to show height schedule		
64 Survey plan to show height difference schedule		
65 Nature and position of survey marks	If RM found deeper then 300mm, not plan. List the state of all survey marks.	All surveyors will dig 150mm without special instructions.
66 Doubts, discrepancies and difficulties in survey plan	Surveyor needs to ensure that there is appropriate land available for the surrounding titles & roads and any excess or shortage is dealt with appropriately. Amend difference tolerance to: 40mm + 175ppm.	The surveyor needs to survey enough land to justify that the proposed survey does not cause any issues or problems with the adjoining parcels and roads. Minor change to be in accordance with datum line tolerance.
67 Comparison of angular checks		

Proposed Regulation	Proposed Change	Reason for Change
68 Surveyor to provide survey certificate	Expand when a survey certificate is required. New certificate for clause 9 (not strict accuracy), 10 (remark) & 11 (identification). Delete reference to Deferred Survey Marks.	Ensure reports and survey plans carry an appropriate survey certificate. New survey certificates.
Part 9: Reporting		
69 Records of verification and validation		
70 Position of permanent survey marks		
71 New permanent survey marks must be shown in sketch plans	Remove reference to GNSS techniques. Locality Sketch Plans must be lodged before the plan is lodged or within 2 months.	The lodgment of a sketch plan is the trigger that creates a PSM in the Survey Control Information Management System (SCIMS). The plan once lodged is assessed against the SCIMS database. Without the sketch plan, it causes delays in the creation of the mark within the SCIMS database and significant cost in following up un-lodged sketch plans.
72 Doubts, discrepancies and difficulties in accompanying comprehensive report		
73 Determinations of boundaries for non-tidal waters and other natural features	All water boundaries require comprehensive report.	Enable efficient approvals process.
74 Approval of public authority	MHWM boundary consent will be required after 20 years, or if no approval or erroneous plan is basis of the current title.	The clause is clarified so that the surveyor is required to refer to a survey plan on public record prepared prior to the change in position of MHWM.
Part 10: Registration of surveyors		
75 Application of Part		
76 Qualifications for registration – the Act, s 36(2)(c)		
77 Required practical experience		
78 Information about applicants		
79 Continuing professional development – the Act, s 36(2)(h)		
80 Conditions of registration as mining surveyor		

Proposed Regulation	Proposed Change	Reason for Change
81 Register of surveyors – the Act, s 15(3)		
82 Certificates of meritorious service		
Part 11: Board of Surveying and Spatial Information		
83 Constitution of Board—the Act, s 27	Update the name “Institution of Surveyors NSW Ltd”, not incorporated. Add the “Association of Consulting Surveyors NSW (ACS NSW)” as one of the professional associations under section 27(2)(c) of the Act.	Allow greater input to the Board from more industry groups.
84 Committees to assist Board—the Act, s 30(3)		
85 Board determinations	Delete reference to “recognized professional training agreement”.	No candidates are using this pathway to become registered.
86 Complaints against registered surveyors – the Act, s 36(2)(i)		
Part 12: Miscellaneous		
87 Students of surveying and surveyor’s assistants		
88 Fees and deposits		
89 Notice of proposed entry to land		
90 Certificate of authority		
91 Authorisation to remove survey marks		
92 Exemptions by Surveyor-General		
93 Repeal and savings		
Schedule 1 **Fees and deposits**		
Schedule 2 **Forms**		
Schedule 3 **Dictionary**	To be consist with the Crown Lands Management Act 2016: bank, bed, lake and river. Remove the definition of stream. Use the term ‘non-tidal’ instead of the description of “lake and stream” to define a non-tidal water boundary.	To enable greater consistency of specific terms, the Crown Lands Management Act 2016 will be the source of all definitions. The use of the term ‘non-tidal’ to describe a water feature that does not have tidal influence is explicitly clear as to what is the defining factor that separates tidal and non-tidal water boundaries.

Proposed Regulation	Proposed Change	Reason for Change
Schedule 1 Bench marks	Re-order into preference of use. Bench mark token has full description. All bolts, nails or spikes combined.	Minor reforms.
Schedule 2 Boundary marks	Line Pegs 3’ x 3’. All bolts, nails or spikes combined. Boundary mark token has full description.	Minor reforms.
Schedule 3 Reference marks	Reference mark token has full description. Nail & wing added.	Minor reforms.
Schedule 4 Permanent survey marks	Most diagrams will have small enhancements. Recess SSM to stop “topping”. Ensure gap between cover box & pin/picket to stop “topping”.	Minor reforms.
Schedule 6 Form 1 Survey certificate	Amendment to survey certificate. Only one date of completion.	Minor reforms.
Schedule 6 Form 2 Survey certificate not requiring strict accuracy	Amendment to survey certificate. Only one date of completion.	Minor reforms.
Schedule 6 Form 5 Land survey & ident certificate	Amendment to survey certificate. Only one date of completion.	Minor reforms.
Schedule 6 Form 6 Consent certificate	New form. Enable approvals and consents to be obtained simultaneously before final plan of survey in finalised.	Enable approvals and consents to be obtained simultaneously in a new digital lodgement/workflow before final plan of survey in finalised.

4 CONCLUDING REMARKS

The current Surveying and Spatial Information Regulation 2017 is due to cease operation on 31 August 2023, and a new Regulation is proposed to commence on 1 September 2023. However, due to high priority for new bills, reformatting of the Regulation to satisfy new drafting styles and standards, the Regulation may be deferred another 12 months, meaning that a maximum extension until 31 August 2024 may be provided.

This paper has provided an overview of the proposed changes and the new structure being considered at this time. Considerable liaison, presentations and communication with industry groups, associations and government agencies and utilities are proposed over the next year or two to obtain comments and ideas for the new Regulation. In addition, it is planned to ensure that new documentation, e.g. updated Surveyor-General’s Directions and updated Registrar General’s Guidelines, new plan forms and certificates, along with updated communication and education programs are provided to inform surveyors of the proposed changes before and after the new Regulation commences.

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Navigating Water Boundaries

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ABSTRACT

The review of Surveyor-General's Direction No. 6 (Water as a Boundary) has been delayed due to a neap tide. Its release is now planned to coincide with the release of the Surveying and Spatial Information Regulation 2023. This is to allow more time for the definitions that need to be refined to be discussed, agreed upon and formalised before the release of the document. There is still much discussion to be had on the fluctuations of understanding about the concepts that underpin water boundaries because there are many points of view and interpretations to consider. The ebb and flow of conversation is paramount to supplying the most considered outcome that will yield the greatest consistency for the profession. The result is intended to be a detailed resource to explain how the industry is to comply with legislation and case law in making valid decisions about the reinstatement of water boundaries. It may be described as a flood of information, however that is preferable to a drought of understanding. A document is required that dispels myths, legends and the folklore of the sea. This paper outlines why context, ethics and transparency are the three most important things when it comes to natural boundaries. Any change that may occur in water boundaries needs to be natural, gradual and imperceptible. The industry needs to remain sure footed on the bank, supported by reports that document the facts. When there are 'Pirates of the Cadastre' roaming about, it is imperative that one must keep their powder dry and not become bogged in the mire of water boundaries.

KEYWORDS: *Water boundaries, legislation, riparian, tidal, Mean High Water Mark, banks.*

1 INTRODUCTION

Boundary definition of natural feature boundaries is considered by a lot of registered surveyors to be one of the most daunting parts of cadastral surveying. The rules do not appear to be clear, and the risk involved in getting the correct answer appears high. Considering that this is sometimes the most valuable land in the area, the process is very different to the approach used when defining right-line boundaries.

The role of the Office of the Surveyor-General is to provide direction to ensure that all natural feature boundaries are surveyed and defined in a consistent manner to allow consistent and reliable outcomes. The reporting requirements that are proposed are to facilitate the transfer of knowledge of what was on the site at the at the time of the last survey and what feature was adopted to the next surveyor or anyone dealing with the plan.

The ability to locate the correct feature is only possible if the surveyor interprets the titling documentation and the law within the context that it was written. The surveyor's role is to relocate the boundary where it was originally placed or to define the boundary for the first time in the position that complies with the intent of the law and the titling documentation.

The review of Surveyor-General's Direction No. 6 (Water as a Boundary) (DCS Spatial Services, 2016; Fenwick, 2021) has been delayed to allow more time for the definitions that need refining to be discussed, agreed upon and formalised. Its release is now planned to coincide with the Surveying and Spatial Information Regulation 2023. The ebb and flow of conversation is paramount to supplying the most considered outcome that will yield the greatest consistency for the profession. The result is intended to be a detailed resource to explain how the industry is to comply with legislation and case law in making valid decisions about the reinstatement of water boundaries.

2 ETHICS IN SURVEYING

Upon becoming a registered surveyor in NSW, we accept that there is an ethical standard we must adhere to as a professional. The Board of Surveying and Spatial Information (BOSSI) has documented what these standards are (BOSSI, 2021). This is not a recently created document but one that has been in existence for a reasonably long time and is occasionally updated. There have been at least two versions of this document published on the BOSSI website since the early 2000s and possibly before.

Regardless of how long the document has been published on the BOSSI website, a code of ethics has always been a major part of the surveying profession. It forms part of the duty of care that surveyors have for the cadastre. It is the basis of the legal system and is documented in case law, particularly in water boundary cases that deal with the Doctrine of Accretion and Erosion (Doctrine).

The BOSSI Ethics and Code of Professional Conduct document (BOSSI, 2021) is found on the BOSSI website under Publications > Determinations and policies, not to be confused with the Code of Conduct: Board and Committees document also hosted there. The document distinguishes between ethics being the framework for conduct (which are enduring principles) and the code of professional conduct being the professional behaviours that reinforce and clarify the ethical standards. However, the line is very grey, and in this paper both the code of conduct and ethics will be referred to by the word ethics because a surveyor is ethically bound to follow the code of conduct.

The document requires the surveyor to do the following (but is not limited to these points):

- Put the welfare and rights of the community before the profession, other surveyors and/or sectional or private interests. This would/should also include the interests of their client.
- Accurately and conscientiously measure, record and interpret all data.
- Exercise unbiased and independent professional judgement.
- Ensure that their practices comply with the law and the guidance in relation to surveying matters.
- Keep their knowledge and skills current.
- Not to undertake work they are not qualified or competent in or have the authority to undertake.

Hence the ethics of surveying require unbiased and fair boundaries to be determined that comply with the law and the legal principles. But how is that to be achieved?

3 CONTEXT OF LANGUAGE

Pike (1982) states: "*Language is not merely a set of unrelated sounds, clauses, rules, and meanings; it is a total coherent system of these integrating with each other, and with behaviour, context, universe of discourse, and observer perspective*."

One of the biggest issues in cadastral surveying is the ability to communicate. Surveyors are great problem solvers, analysts, mathematicians, have a wealth of knowledge in a vast range of disciplines and excel in dissecting data in the finest detail. However, when it comes to interpreting language, they often become fixated on the meaning of words in isolation. They fail to read the whole sentence, the whole paragraph and the whole document. They fail to analyse the context of the document, why a statement is in a particular location and consider the information around that statement. They do not understand the context of the words with the document as a whole.

The Honourable Justice John Middleton gave the following five insights about statutory interpretation being mostly common sense (Middleton, 2016):

"*The principles governing the interpretation of a statute by a court in a common law setting are, by definition, common law principles and will evolve over time*."

"*As stated by D C Pearce and R S Geddes in their book on statutory interpretation: Legislation is, at its heart, an instrument of communication. For this reason, many of the so-called rules or principles of interpretation are no more than common-sense and grammatical aids that are applicable to any document by which one person endeavours to convey a message to another. Any inquiry into the meaning of an Act should therefore start with the question: What message is the legislature trying to convey in this communication?*"

"*Undoubtedly, there is a need for readily understandable and consistent principles to guide the interpretation of legislation. These principles should basically be guided by common sense, and we should not be blinded by too many rules, over-analysis, or mechanical or scientific analysis. Trawling for rules and cannons of interpretation is not the correct starting point. The starting point should always be to look at the words, their context, and the purpose of the legislation, then applying that to produce a result that is both fair and workable in the particular fact situation you have before you. In addition, a judge should also recall, having regard to the common law principles of precedent, to be mindful of the application of the interpretation of the statute to other cases.*"

"*The High Court of Australia by its actual analysis … has indicated the current approach to statutory interpretation involving the* ***use of text, context and purpose****. This approach to statutory interpretation is based upon various assumptions and a basic common-sense approach to interpreting a statute*."

"*Whilst it would be foolish to regard all statutes as being able to be read and understood by the lay uninitiated citizen, this should at least be an aim in drafting legislation with precision and clarity. Of course, many statutes are interpreted every day by ordinary citizens, public administrators, and non-legal advisers, probably without difficulty. This is important so that the daily affairs of people can be readily guided by the statute, and the expectations of those people are not thwarted by an interpretation of a statute beyond lay comprehension.*"

From this, it seems clear that trying to interpret words without the context is a fraught endeavour. Considering the law does not need to be any more complicated than necessary, surveyors should not be overcomplicating something that should not be complicated. It is the role of a lawyer to argue the semantics of law and legal principle. As surveyors, we should accept the law at face value and interpret it in the context that it was written and intended, bearing in mind the whole of the content and not extracting just those parts that suit the argument while leaving those that do not help the cause.

4 THE LAW OF THE SEA

4.1 Case Law

This section presents a selection of cases that form the basis of water boundary law. There are numerous others, but they are all linked and describe various parts of the same set of principles. The aim of this paper is not to sway the reader into any particular direction, other than to read the words in their original context, as this can only be done by quoting the relevant sections of the cases. This is obviously limited as it is not possible to quote the whole case. At the end of the quotes, parallels are drawn between cases and later in the paper contrasting opinions are outlined.

4.1.1 Attorney-General v Chambers 1854

Context: What is the limit of a Crown grant? How to define a tidal margin?
Surveying principles: Land granted and Mean High Water Mark (MHWM).

There is a lengthy discussion regarding submissions from both sides, but the conclusion by the Lord Chancellor (Lord Cranworth) is insightful and simple in application (extract from page 490):

> "*In this state of things, we can only look to the principle of the rule which gives the shore to the Crown. That principle I take to be that it is land not capable of ordinary cultivation or occupation, and so is in the nature of unappropriated soil. Lord Hale gives as his reason for thinking that lands only covered by the high spring tides do not belong to the Crown, that such lands are for the most part dry and manurable; and taking this passage as the only authority at all capable of guiding us, the reasonable conclusion is, that the Crown's right is limited to land which is for the most part not dry or manurable.*
>
> *The learned Judges whose assistance I had in this very obscure question point out that the limit indicating such land is the line of the medium high tide between the springs and the neaps. All land below that line is more often than not covered at high water, and so may justly be said, it, the language of Lord Hale, to be covered by the ordinary flux of the sea. This cannot be said of any land above that line, and I therefore concur with the able opinion of the Judges whose valuable assistance I had, in thinking that medium line must be treated as bounding the right of the Crown.*" Lord Cranworth

From the Attorney-General v Chambers 1854 case, it should be noted that it is the "*line of the **medium** high tide between the springs and the neaps*", not the arithmetic mean or the median or any other statistical function, and therefore any argument about the word "between" is a semantic argument about the meaning of a word taken out of context.

Further, the current definition of MHWM is only a partial application of the intent of this ruling. This application does not take into account the nature of the land. Is the land useful to the landholder or is it not? There is a principle that land which is not ordinarily cultivatable or occupiable is by its nature unappropriated soil and remains in the Crown estate.

Therefore, the result of this ruling is the Crown intended to grant all the useful soil and the Crown is to keep the soil that is uncultivatable, not manurable, not occupiable or that is mostly wet (being land below the medium tide). This is not a scientific definition but for the 1850s very reasonable when the whole outcome is considered as one concept and not broken up and partially applied.

This paper does not imply that the definition of MHWM in the Surveying and Spatial Information Regulation is going to change. This paper identifies that there is scope in the application and interpretation of the definition of MHWM based within the law to assist with application of the definition in locations that are difficult and where rigorous measurement of the tides does not yield an unwavering result.

4.1.2 The State of Alabama v The State of Georgia 1859

Context: The Supreme Court of the United States of America. Where is the border between two states on a river and how to define something that is several hundred miles long with varying terrain from steep banks to marshland and swamps?
Surveying principles: The bank of a non-tidal water feature.

A little background information is required for this case. In 1851, on this same river a case was heard between Howard v Ingersoll. The same court presided over both cases, and the result of the 1859 case overturned the 1851 result with an erratum noted in the 1859 summary (extract follows):

> "*The boundary line between the States of Georgia and Alabama depends upon the construction of the following words of the contract of cession between the United States and Georgia, describing the boundary of the latter, viz: 'West of a line beginning on the western bank of the Chattahoochee river, where the same crosses the boundary between the United States and Spain, running up the said river and along the western bank thereof.'*
>
> *It is the opinion of this court that the language implies that there is ownership of soil and jurisdiction in Georgia, in the bed of the river Chattahoochee, and that the bed of the river is that portion of its soil which is alternately covered and left bare, as there may be an increase or diminution in the supply of water, and which is adequate to contain it at its average and mean stage during the entire year, without reference to the extraordinary freshets of the winter or spring, or the extreme drought of the summer or autumn.*
>
> *The western line of the cession on the Chattahoochee river must be traced on the water line of the acclivity of the western bank, and along that bank where that is defined; and in such places on the river where the western bank is not defined, it must be continued up the river on the line of its bed, its that is made by the average and mean stage of the water, as that is expressed in the conclusion of the above recited paragraph.*
>
> *By the contract of cession, the navigation of the river is free to both parties.*

> *See the case of Howard v. Ingersoll, 13 Howard, 381, and the correction of its syllabus in the errata in 14 Howard in this, that 'the boundary line runs along the top of the high western bank,' instead of 'the boundary line runs up the river, on and along its western bank, and the jurisdiction of Georgia in the soil extends over to the line which is washed by the water wherever it covers the bed of the river within its banks'*." Wayne J.

Contained within this case is an in-depth discussion regarding the bed and the variety of ways it is defined around the world. However, the outcome is captured very clearly in the summary.

The errata provides clarity to any confusion a reader may have about where the boundary is due to old English terms such as 'acclivity' for the situation that involves a defined bank. If there is any doubt about what an ill-defined bank is, there is also a description at the end of Georgia's declaration that clarifies this.

For many years, there has been controversy about how to interpret the definition of the 'bed'. This is the origin of the words that have been adopted and therefore they should be interpreted in the context that they were written, and consideration should be given to the paragraph below the words that have been adopted into legislation as this provides a clear interpretation of how these words were meant to be understood by the judges that created the phrase.

4.1.3 Overland v Lenehan 1901

Context: The case is about an erroneous description of land in a subdivision.
Surveying principles: Collecting evidence and interpreting documents.

> "*In my opinion the question to be determined is what was the western boundary of subdivision 10 as understood by the persons concerned at the time when the mortgage of subdivision 1_B and the transfer of subdivision 10 were executed. In the case of Donaldson v Hemmant (ante p.35) I quote from Taylor on Evidence (4th Ed., p.1029) some rules which, I think should be applied in construing instruments relating to land for the purpose of determining the identity of the subject matter. They may be summed up by saying that most weight should be given to those points on which the parties at the time were least likely to be mistaken.*" Griffith C.J.

There is no water boundary involved, but this case does require the judge to consider the evidence that was available to the parties of the transfer. Hence, when trying to understand what land was granted in a Crown grant, surveyors are undertaking the same process as described here. Consider how this affects the interpretation of the Crown grant when the boundary is described as the bank or the river.

This paper does not imply that the Crown grants are erroneous. The aim is to correctly interpret the instrument that defines the land. To do this, the document must be read in context, with the intent that it had at the time it was written and with the understanding of those that were dealing with the grant at the time. What is the most unmistakeable feature of a bank, considering the water level could be at any height? What does the average person consider the limit of the river if it is limited by the bank, bearing in mind that the banks from part of the river?

4.1.4 Kingdon v The River Hutt Board 1905

Context: There are 14 questions answered by this case in the Supreme Court of New Zealand. The River Hutt is a river with defined banks and an irregular flow. There was a claim for Ad Medium Filum Aquae and a dispute over the ownership of shingle beds. In NSW, this case is most well known in relation to defining a bank.
Surveying principles: The bank of a non-tidal water feature.

> "*The Hutt River is a river in a river district constituted under 'The River Boards Act, 1884', and within the jurisdiction of the respondent Board. It has defined banks, but the flow of water between such banks is irregular. During the dry months, and for the greater part of the year, it flows in a small channel considerably to the east of the claimant's land. In wet weather the flow is greatly increased, and seven or eight times in a year during such wet weather the water flows from bank to bank, and this flow is called by the witnesses 'ordinary freshes'. In very wet weather the river is 'in flood', and then it overflows its banks.*" Stout C.J. (p.156)

The concept that is being portrayed here is that all rivers consist of low flows and high flows. In New Zealand on this river, the high flow occurs apparently seven or eight times a year. In NSW, they occur very randomly as here there are long drought cycles, some periods of wet weather that cause high flows and then occasionally there are floods. Sometimes there are many floods in a row, but this does not change the concept being put forth.

The concept put forth is that even though there may be a small channel that contains the low flow, that low channel is not the limit of the river. The limit of the river is another bank that contains the high flow before flooding occurs.

4.1.5 Williams v Booth 1910

Context: An appeal to the High Court of Australia where an Intermittently Closed and Open Lake or Lagoon (ICOLL) became closed to the sea by a sand bar. Claims for Ad Medium Filum Aquae were lodged and claims of accretion made. The lagoon was some 62 acres in size and had largely dried up at the time the case was heard.
Surveying Principles: The Doctrine of Accretion and Erosion, Ad Medium Filum Aquae application to marine lagoons or ICOLLs and the interpretation of documents defining land.

> "*Held, also, that the medium filus rule is not applicable to marine lagoons, and that if it were so applicable, the fact that such lagoons are substantially part of the sea, and may be of public use for the purposes of fishing and navigation, would exclude the application of the rule in the present case.*" Griffith C.J. (p.342)

There is discussion throughout the case that debates the legal reason why this decision was reached, but the outcome is all that is relevant to surveying. All that a surveyor needs to decide is whether they are dealing with an ICOLL or not, and that will determine if Ad Medium Filum Aquae applies or not.

> "*The effect of that contention is that a large quantity of Crown land has suddenly become private land. The principal of accretion is not applicable to a change of that kind.*" Griffith C.J. (p.345)

A consideration of one part of the Doctrine: Was the change gradual or sudden? The claim was that there was a sudden change that occurred at the time the sand bar closed and therefore the change was not gradual. However, there is more in this statement. The indication of a large quantity of land (some 62 acres) overnight. This is also a consideration of the concept ‘gradual’.

On page 346 of the case, there is a very interesting judgement made by Griffith C.J. regarding having all of the correct facts before making a decision. This is of immense importance to the surveying profession and is strongly implied but not explicitly stated in the ethical guidelines supplied by BOSSI (2021).

On page 350, there is an excellent explanation by Griffith C.J. about how a large quantity of land cannot one day belong to the King and the next belong to a freehold owner, occurring at the instant the sand bar closed. There are some references to Hall’s essay and the beginnings of a discussion about imperceptibility: “*The word ‘imperceptible’ refers to the slowness of the additions to the soil.*” However, more clarity is provided later in the case. This page adds more context to the application of the concept of ‘gradual’ more than imperceptible.

> “*The first rule of interpretation applicable to any written contract is to ascertain the intentions of the parties by construing the language they have used according to its ordinary meaning.*” O’Connor J. (p.352)

In this statement the judge explains that no document can be misconstrued by inferring the meaning of words from a different time period when interpreting an instrument of land. Instruments of land are documents of agreement between two parties that are to take effect at the time of signing, and therefore we must read the document through the eyes of the two parties involved in the document. To read the document in any other way is an injustice to the parties involved, and there is a strong probability that the interpretation will result in the incorrect outcome.

> “*In Hall’s Essay on the Sea Shore, 2nd ed., at p. 117, the true nature of the accretion of which a land owner can take advantage against the Crown is clearly explained. ‘It is not,’ he says, ‘indeed, either the sudden or the gradual nature of the event which governs the law, but the perceptible or imperceptible nature of the acquisition; and therefore the direction of the evidence will be to show the greater or less degree of distinctiveness and certainty with which the quantum of soil claimed can be ascertained to have accrued within time of memory. Whatever reason and common sense denominates imperceptible and indefinable, or which even if perceptible and definable is still too minute and valueless to appear worthy of legal dispute or separate ownership, will be deemed part of the adjoining soil, and, as it were, to have grown out of it. In all other cases the King's right will attach.’*” O’Connor J. (p.356)

The first important point to note in the above paragraph is that **it is not the sudden or gradual nature of the event** which governs the law, but it is whether the change occurred by an imperceptible process. It would appear form the above passage that the rules of the Doctrine are not hard and fast as we would be led to believe, but there is limited flexibility within the limits of reason. Consideration must be made to the fair and equitable exchange of land and the intention of the grant. Any grant bound by the river of the bank had the intention that the natural feature would remain the boundary and if the river boundary moves in a fair and equitable manner, so does the boundary.

> "*Various authorities were cited to show that accretion arises only by imperceptible addition to property, and with one exception I make no further reference to them than to say that the principle they affirm is opposed to the respondent's view. That exception is the now classic observation of Alderson B. in re Hull and Selby Railway (I), that 'that which cannot be perceived in its progress is akin to be as if it never had existed at all'.*" Issacs J. (p.111)

An interesting side note is that sometimes, particularly in the old cases, the term 'gradual, slow and imperceptible' is used. The grouping should imply that slow is interchangeable with imperceptible as per the discussion on page 350 as opposed to be used to consider the concept of 'gradual'. However, imperceptible has a very specific meaning, being that an observer cannot see any change occurring (see discussion in the Southern Centre of Theosophy v The State of South Australia 1982 case in section 4.1.9).

4.1.6 Yukon Gold Company v Boyle Concessions Limited 1916

Context: A mining right boundary dispute in British Columbia. Does a 1916 mining rights boundary move due to the Doctrine if the river moves due to flooding?
Surveying principles: The Doctrine of Accretion and Erosion.

> "*The mining rights and areas secured by the due location of river claims are fixed by said location once and for all, and are not subject to diminution by erosion any more than they are entitled to augmentation by accretion.*" Martin, J.A. (p.103)

At first glance this case does not have any impact on the application of the Doctrine as the Doctrine does not apply to this case. However, it was discussed, and the fundamental concepts are still applied.

> "*Under the regulations then in force the side boundaries were declared to be low-watermark as it was on the 1st of August of the year in which the lease was granted.*" MacDonald C.J.A. (p.111)

This paragraph states the reason why the Doctrine does not apply to this case. Mining rights in the Yukon gold fields in the early 1900s are limited by right line boundaries, not ambulatory boundaries. This is included for completeness, and it is important to understand the context of the case and why certain points apply or not.

> *"By the action of the river and of surface water, part of the river bank included within the boundaries of said claim No. 12 have become eroded and submerged. This erosion was not gradual or imperceptible, but occurred in the spring of each year: the encroachments in the three years in question here approximate 100 feet. … The authorities to which we were referred shew that as between landowners on opposite sides of a river ownership does not change in case of sudden erosion or accretion, such as took place yearly in this case. This is a rule of common law, and unless it be inapplicable...*" MacDonald C.J.A. (p.112)

This is an interesting paragraph, which could be misconstrued to mean that erosion by flooding does not comply with the Doctrine. But consider the context in the case along with the other arguments, and it does not mean that at all. This paragraph supplies no detail as to how to interpret or apply the Doctrine. There is no reasoning as to why the erosion is deemed to be sudden. It is merely a statement that confirms that in this case the erosion was deemed to be sudden erosion and that does not comply with the Doctrine.

> "*In these regulations 'river bed' is defined to mean 'the bed and bars of the river to the foot of the natural banks', and by section 4.*" Galliher J.A. (p.120)

Here is another interesting side note about statements made in court cases. This is specific to the Yukon Mining Regulation, which makes sense due to the lease area being for dredging and that requires the land to be covered by water. Hence, this is not applicable to the conversation about how to define a river 'bed' in NSW.

> "*The trial judge has decided as a fact that the erosion does not belong to the class which is referred to in the authorities as gradual or imperceptible, nor yet to the class where it is caused by sudden changes that occur by a violent effort of nature, but rather to an intermediate class, being due to the nature of the soil forming the surface of the land being principally composed of muck, and the action of the waters caused by the melting of the snow in or about the month of June in each year. I have scaled the distance on map 1.2, and roughly I should say that the bank has eroded at the average rate of 25 feet per year between the years 1910 and 1913. I do not think this could by any stretch of imagination be deemed to be gradual or imperceptible, but occurs at certain periods of the year and in very considerable quantities, so that the trial judge, in my opinion, put the case rather favourably to the defendant in terming it an intermediate change. I should say it partakes rather of the nature of sudden change, and in that view the authorities are clear that the plaintiff does not lose its right.*" Galliher J.A. (p.121)

The case does consider if the Doctrine would have applied to these boundaries if they were ambulatory. The concept of imperceptible is not considered in detail, even though it is mentioned. However, the erosion appears to be considered and would not comply under the concept of a gradual change. The change is considered "considerable in size" and therefore worthy of legal dispute as they are mining for gold of reasonable value. Also consider the size of the area lost compared to the width of a lease that is only the width of the river. Hence why this is considered of the nature of sudden change.

It is important to note that none of the judges stated that the change failed to comply with the Doctrine simply due to the fact that the change occurred by the action of flooding. Flooding is mentioned and may be the reason that the change occurred, but it is not the reason that the change is sudden and does not comply with the Doctrine. The change is substantial, recognisable and valuable; the change is not fair and equitable.

4.1.7 Humphrey v Burrell 1951

Context: A case where a very large flood carved a new channel through a property, cutting off a substantial portion of land (several acres).
Surveying principles: The Doctrine of Accretion and Erosion.

> "*In Secretary of State for India v. Rajah of Vizianigaram (1921, L.R. 49 Ind.App. 67), the Court (per Lord Carson, at pp. 71, 73) pointed out that the application of the test 'gradual' to rate of progress necessary to satisfy the rule when used in connection with English rivers was not necessarily the same when applied to the rivers of India, saying 'The recognition of title by alluvial accretion is largely governed by the fact that the*

> *accretion is due to the normal action of physical forces; and conditions of Indian and English rivers differ so much that what would be abnormal and almost miraculous in the latter is almost commonplace in the former.'*
>
> *In New Zealand the application of the rule is complicated by the fact that there is a great diversity of streams and rivers – some comparable to the rivers of England, flowing in well defined courses, with banks well consolidated, through country cultivated and stable, others springing from the mountains or hills and becoming at times raging torrents, swollen and tumultuous, and which, whilst in that state, are prone to carve out new channels; some are narrow, and some have a width from bank to bank of two miles or more. There is indeed an infinite variety.*" Greeson J. (p.628)

The application of a principle must be undertaken with the recognition of where it is being applied. Expecting to get a meaningful result by applying rules developed in another country or even in a different climate is misguided and devoid of context. Without context, any words or concept will fail to have significance and will result in an absurd outcome that defies logic or common sense and the intention of the original document. Furthermore, it will not be fair or equitable to the parties involved, and it will be highly likely that the next person to be involved making the decision will come up with a different outcome. The context of the situation being considered is an integral part of the outcome decided.

> "*In my opinion, the cumulative effect of the evidence is to establish affirmatively that the river took up its present course as the result of a sudden break at the time of a very high flood, when it carved out for itself a new course substantially the same as that in which it now flows; but even if the evidence, considered as a whole, fails to do this, at least it fails to establish (as I hold defendant must do to succeed) that by a gradual accretion, imperceptible in its progress, this large area became the property of the defendant.*" Greeson J. (p.628)

As stated in Hall's essay mentioned by O'Connor J. in Williams v Booth 1910 (see section 4.1.5) and here again confirmed by Greeson J., it is not the fact that a flood occurred that is the reason the change fails the Doctrine. It is the fact that the change has not occurred by accretion, i.e. the river slowly moving across the landscape in an imperceptible motion. The change occurred by erosion cutting a new path through the property and severing the land. This is not the intent of the Doctrine.

4.1.8 Ward v The Queen 1980

Context: Heard in the High Court of Australia, this case is to determine the location of the border between NSW and Victoria based on the words in the Separation Act 1855 and the Constitution. The case has a very specific location. The result of this appeal will determine in which jurisdiction a crime occurred and which law applies. However, the concepts in this case can and have been applied to other locations as this case forms the basis for the joint Guidelines for the Determination of the State Border between New South Wales & Victoria along the Murray River.
Surveying Principles: The bank of a non-tidal water feature.

> "*Whatever ambiguity might remain in the description 'Watercourse' when used alone, in my opinion 'the whole Watercourse' of a river definitely means the area between the*

> *extremities of the banks of the river: they, except in times of flood, determine the course of the river.*" Barwick J. (p.2)

This paragraph reinforces the concepts in The State of Alabama v The State of Georgia 1859 (see section 4.1.2), i.e. the concept that the river is contained by the channel that contains its flow at all stages until it breaks its banks and flooding occurs. Interestingly, the US case from 1859 was not referenced in the Ward case but the same outcome was arrived at.

> *"38. So much for some of the practical difficulties involved in a resolution of the question of the Murray River boundary. This Court is neither a treaty-making body nor a boundaries commission, nor is it presently concerned with the resolution of such a dispute between states as that to which s.(iv.) of the Constitution refers … although in arriving at a decision it cannot be unaware of the broader consequences that that decision may entail, … Reference was made in the argument of the Solicitor-General for Victoria to the weight given to matters of convenience where the United States Supreme Court has been concerned with border adjudication.… The approach of the United States Supreme Court in Howard v. Ingersoll (1851) 13 How 381 (14 Law Ed 189) and in Handly's Lessee v. Anthony [1820] USSC 19; (1820) 5 Wheat 374 (5 Law Ed 113) as well as in subsequent cases involving the determination of border questions between States, …*" Stephen J. (p.16)

The above paragraph shows that while this case has a specific purpose it also noted that it will set precedents that must be followed. The confusing thing about this statement is the understanding that Howard v Ingersoll 1851 was a case about the state border because it is not. Howard v Ingersoll is a case about a mills water wheel that had stopped working by the construction of a dam built by another party.

The State of Alabama v The State of Georgia 1859, which overturned Howard v Ingersoll 1851, is the case about the state border, yet this case is not referenced in the decisions of the Ward v The Queen case with the same context. This is important to understand before reading the next quote because Stephen J. refers to Howard v Ingersoll when discussing the banks of a river. It is not clear why, but the judge obviously thought it important to include this point.

> "*54. My conclusions concerning s. are, then, that it is expressed in language which refers not to the flowing waters of the Murray but, rather, to the contour feature within which those waters flow: that, although it was the product of problems relating to the collection of customs duty on Murray River traffic, it is expressed to be, and takes the form of, a measure for defining territorial boundaries: that in taking this form it gives effect to the proposals of its initiators in New South Wales: that, on its proper construction, it declares the whole of the contour feature, to the top of the southern bank, to be the territory of New South Wales. It follows that the boundary line between the States runs along the top of the southern bank of the Murray, all territory to the north being within New South Wales. In referring to the 'bank' of the river / adopt the description given in Howard v. Ingersoll (1851) 13 How, at p. 427 (14 Law Ed 209): 'the banks of a river are those elevations of land which confine the waters when they rise out of the bed'. In Jones v. Mersey River Board (1958) 1 QB 143, Jenkins L.J., after citing with approval this passage from Howard v. Ingersoll (1958) 1 QB, at p. 151, pointed out that the identification of the 'bank' at any particular point along a river 'must be a question very largely of fact to be decided in each particular case by reference to the size and habits of the river, the geological composition of the land, and the level of the land as compared with the river,*

> *and no doubt, other circumstances of that kind'. The relevant topography at the site of the shooting in the present case leaves no room for doubt: the bank is well defined and its top can be instantly recognized. His Lordship, having regard to the statutory context there in question, would have included in 'banks' rather more than 'the slope or vertical face' which confines the waters when they rise out of the bed, extending its meaning to land adjoining the river (1958) 1 QB, at p. 151. However in the present case it will be along the top or upper edge of 'the slope or vertical face' of the southern bank that the boundary between the States is to be found (at p. 337).*" Stephen J. (p.22)

The conclusion of the Ward v The Queen case is that the border of NSW and Victoria is the top of the southern bank, the point that is unable to contain the water when flooding occurs. This therefore defines the limit of the watercourse.

The context of this case is not to define the limit of the 'bed' and seems to imply that the banks are not part of the bed even though every other concept of a river includes the bank as part of the bed. Also bear in mind that both The State of Alabama v The State of Georgia and Ward v The Queen result in the same outcome.

4.1.9 Southern Centre of Theosophy v The State of South Australia 1982

Context: Considered by the Privy Council, this case considered if the effects of wind-blown sand could be accepted as accretion and whether the Doctrine applies to non-tidal lakes. The latter will not be considered in this paper as it does not apply to NSW as noted in the case.
Surveying principles: The Doctrine of Accretion and Erosion.

> "*Before examining the authorities, which are copious and in their result clear, their Lordships find it advisable to consider briefly the nature of the doctrine of accretion. This is a doctrine which gives recognition to the fact that where land is bounded by water, the forces of nature are likely to cause changes in the boundary between the land and the water. Where these changes are gradual and imperceptible (a phrase considered further below), the law considers the title to the land as applicable to the land as it may be so changed from time to time. This may be said to be based on grounds of convenience and fairness. Except in cases where a substantial and recognisable change in boundary has suddenly taken place (to which the doctrine of accretion does not apply), it is manifestly convenient to continue to regard the boundary between land and water as being where it is from day to day or year to year. To do so is also fair.*" Lord Wilberforce (p.4)

The beginning of this case is a wonderful discussion on the holistic approach of applying the Doctrine. The discussion maintains that a water boundary is a boundary of convenience, but not necessarily a convenient boundary. It is a boundary based in fairness and equity not just to the landowner but to the adjoining owners and all interested parties. Water boundaries are a matter of ethics more than measurement and science.

> "*Since Bracton, the requirement of imperceptibility has been affirmed by the highest authority, R. v. Lord Yarborough (1828) 2 Bligh N.S. 147; Attorney-General v. M'Carthy (I.c.). The word, of course, has to be interpreted. In R. v. Lord Yarborough, Abbott C.J., giving the judgment of the King's Bench ((1824) 3 B. and C. 91 at page l07), said that it must be understood as 'expressive only of the manner of accretion … and as meaning imperceptible in its progress, not imperceptible after a long lapse of time'. The gain to the land in that case, by recession of the sea, was said to have been on average, over 26-*

> *27 years, of about 5½ yards in a year, or (according to other witnesses) greater and it was held that the jury could properly hold this to be imperceptible. In the opinion which Best C.J., on behalf of the judges, later gave to the House of Lords there is this passage: 'Land formed by alluvion must become useful soil by degrees, too slow to be perceived. What is deposited by one tide will not be so transient as to be removed by the next. An embankment of a sufficient consistency and height to keep out the sea must be formed imperceptibly'. (2 Bligh N.S. 147, 158.)*" Lord Wilberforce (p.8)

One could take from this that there is a time component to accretion, but they would be mistaken. Accretion does not need to take a long time, just long enough to become soil or usable consolidated material. The same rules apply to accretion as erosion. Erosion may only take minutes to occur, provided it is minute (small), un-noticeable and valueless. Therefore, accretion can occur in the same time period. It is really a question of whether the addition is soil or loose sediment that can be washed away. The other side of this concept that is confused with time is quantity and value. If the accretion is a large and valuable area, was it formed gradually? If a very large area is claimed, then it must have been formed by lots of small un-noticeable changes and be unlikely to revert back to the original state any time soon.

> "*Another, and perhaps more realistic, explanation is (as already suggested) that the rule is one required for the permanent protection of property and is in recognition of the fact that a riparian property owner may lose as well as gain from changes in the water boundary or level. But whatever is the true explanation of the rule – and there may well be more than one reason for it – what is certain is that it requires a distinction to be made between such progression as may justly be considered to belong to the riparian owner, and such large changes or avulsions as should more properly be allocated to his neighbour. Since there is a logical, and practical, gap or 'grey area' between what is imperceptible and what is to be considered as 'avulsion', the issue of imperceptibility or otherwise was always considered to be a jury question (see Attorney-General v. M'Carthy, i.e. page 296 per Gibson J.).*" Lord Wilberforce (p.9)

This is an interesting passage that confirms the thoughts of Middleton (2016) that were previously discussed. The law is not meant to be any more complicated than necessary. As these are the boundaries of the land owned by the public, they should be able to understand what they own and where they are entitled to farm or frolic. Further, it revolves around the ethics of the outcome and whether it passes the 'pub test', i.e. is it fair and equitable.

> "*The evidence certainly shows, and their Lordships would accept, that in certain conditions of wind and weather (their Lordships do not know how frequently these occurred) movement could be detected by an observer – not at a great rate but still detectable. Professor van der Borch said variously: 'noticeable in the course of a day with a yard as an upper figure – you would notice it (the movement of a drift) within a day in some exceptional cases with certain wind directions and velocities … you may certainly see sand moving in a slip face within an hour which means if slowly moving they would move a millimetre or centimetre or something like that' (one may compare this with the movement of the hour hand of a clock).*
>
> *Their Lordships find this lacking in the vital precision. Movement of parts of the dunes, or of drifts of sand upon the dunes, is not the same thing as movement of the land boundary out into the sea. The one may be observable but does not, of its nature, constitute the other. The real question is how long it takes for a consolidation to take*

> *place bringing about a stable advance of the land. And the evidence takes the form 'I would expect that' rather than 'I saw and measured'.*" Lord Wilberforce (p.9-10)

The concept of imperceptibility seems complex but can be explained in very simple terms. If an observer cannot see the boundary moving, then any movement is imperceptible. If the observer needs to place a marker and see if they can estimate the movement, it is imperceptible. Furthermore, just because the observer can see sediment moving does not mean they can see the boundary moving. Consider the grains of sand at the beach, they swish back and forth, but the observer is unable to determine if more grains are coming or going. Any change that may be occurring is imperceptible but yet they can see something happening.

This paragraph also comes back to the point about consolidation. Sediment is not accretion until it is consolidated and useful or has become soil depending on what the sediment is made from.

> "*Their Lordships are far from confident that the evidence taken as a whole gives a complete and reliable picture of the movement of sand between 1888 and 1975, but they are of opinion that the figures arrived at by Mr. Armstrong, based as they are upon actual observations by air photograph, over 30 years, give reasonably acceptable evidence as to the long term rate of advance. This is not inconsistent with this advance having taken place unevenly, and at times by perceptible jumps, but it was for the trial judge (who in fact viewed the location) to consider together the two indications as to long term and short term movement. Taken together they provide material on which, in their Lordships' opinion, his Honour was entitled to come to the conclusion that the movement was imperceptible within the meaning of the authorities. The case was finely balanced but the evidence was not such that he was bound to draw an inference that any sudden movements of the dunes were necessarily accompanied by consolidated intrusions of the shoreline into the lake. On this point therefore their Lordships uphold the finding of the trial judge.*"
> Lord Wilberforce (p.10)

Finally, the conclusion of the case and some very important concepts are revealed. A perceptible jump, meaning a change that the observer can see after the event, is deemed accretion if the observer could not see it occurring. Also not all accretion must occur in a slow continuous growth, it may grow quickly, then pause and then grow quickly and pause. It may grow slowly for a while and then quickly again or it may stop. Each change just needs to be un-noticeable while it is occurring. These changes are known as perceptible jumps. Consider many small un-noticeable, valueless changes that occur by many floods. Does this meet the criteria?

4.2 Crown Grants

On pages 348 and 349 of the Williams v Booth case in 1910 (see section 4.1.5), there is an interesting discussion regarding rules of construction of Crown grants and Ad Medium Filum Aquae, however for brevity it has not been included. The point was also made by Issacs J. (p.352) of the same case as noted above. This discussion supports the concept that Crown grants should be read at face value and as the ordinary person would understand them, unless there is some compelling rule of interpretation that should apply.

Crown grants are the first transfer of that land out of the Crown estate. As such, they are the primary document that defines what was granted. Land cannot be excised out of the Crown estate unless it has been granted by a Crown grant. The majority of the Crown grants that create an ambulatory boundary along a natural feature refer to the bank, a river, the cliff or watershed/

ridgeline or some other natural feature. There are some exceptions of course, such as swamps and marshes as they (in the majority of cases) do not have definable edges. These grants should be considered as granting land to a right-line boundary as defined by the first survey.

4.3 The Surveying and Spatial Information Regulation

The requirement of clause 19(1) of the Surveying and Spatial Information Regulation 2017 (NSW Legislation, 2023a), which has existed in many previous editions of the Regulation, appears to have the same outcome as Chief Justice Griffith explained in Overland v Lenehan 1901 (see section 4.1.3). This is the requirement to replace the original intention based on the evidence that is least likely to be mistaken, i.e. the original pegs marked on the ground or the bank, MHWM or natural feature that was defined in the first survey.

4.4 The Crown Lands Management Act 2016

Section 13.3(9) of the Crown Lands Management Act 2016 (NSW Legislation, 2023b) includes a list of definitions for terms that relate to natural features. The most notable that is not discussed is the term ‘river’. The other terms are lake, bed and bank. Some of these terms are discussed ad-nauseam and yet there is no resolution or agreement as to how these terms should be applied.

> “*River includes any stream of water, whether perennial or intermittent, flowing in a natural channel, and any affluent, confluent, branch or other stream into or from which the river flows.*”

The Crown Lands Management Act 2016 only refers to these terms for section 13.3 as this is specified in section 13.3(9) “*In this section*”. The rest of the document uses the definition in section 5.33 or the common English meaning of watercourse.

This raises a very interesting question about what the intention of section 13.3 is. Unfortunately, that is a question of law and beyond the scope of this paper. However, no evidence has been found, including researching the Hansard records from 1931, that shows that the intention was anything other than to describe the rights of the adjoining owner to use the ‘bed’ of any water body.

5 COMPARISION OF PHILOSOPHIES

5.1 Definition of the Bank for Non-Tidal Waters

The first point worth noting is that there is a definition of ‘river’ in the Crown Land Management Act 2016, yet it is not used when surveying a Crown grant that is bound by the word river in the Crown grant for that specific lot. Why should there be two ways for defining the same river just because one grant stated river and the next grant stated bank? This is illogical. However, it would seem reasonable that the same location on the ground is measured regardless of what word is used in the Crown grant.

Hence the term bank should mean:

- The channel capable of containing the/any perennial or intermittent river.
- The channel capable of containing the/any perennial or intermittent river that is also the limit of the bed.

Or perhaps:

- The channel capable of containing the/any perennial or intermittent non-tidal water without reference to flooding that is also considered to be the limit of the bed.

This deals with the defined bank scenario and is also similar to the existing definition. In NSW, ill-defined features should not be used as boundaries. This has been the case since the 1886 Instruction to Licenced Surveyors. The intention is not to reword the definition but to understand how to apply the definition we have.

Another way to consider this is through the primary cases from section 4: The State of Alabama v The State of Georgia 1859, Kingdon v The River Hutt Board 1905 and Ward v The Queen 1980. However, Attorney-General v Chambers 1854, Williams v Booth 1910, Overland v Lenehan 1901 and Humphrey v Burrell 1951 also have a role to play.

When these cases are read in context and in conjunction with each other, they create the concept that the Crown grant granted all the land that satisfies the following points (excluding the concept of Ad Medium Filum Aquae, which is a separate rule of construction and only considered after the initial grant is understood):

- All the useable land that was ordinarily occupiable or cultivatable.
- All the land to the top of the bank before flooding occurs.
- All the land that can be flooded from time to time, but not the land capable of containing an ordinary fresh in the river.
- The bank should be easily identifiable and unmistakeable at any time except during a flood.
- The bank should be the natural feature that an ordinary person would expect to contain the whole flow of the water except during times of flooding.
- The boundary is designed to be ambulatory; it will move in accordance with the Doctrine.

Interpreting Crown grants that are bound by a river or by the bank should be simple and straight forward. When the grant is read in context and taken at face value using the terms as they would be used at the time the grant was written, the river or bank should have the meaning as implied by several court cases that are mentioned above.

However, by contrast, surveyors construct elaborate arguments using the cases above to define the boundary as the mean and average stage for every river. These arguments consider such points as the river does not get regular freshes, it is in drought most of the time and therefore the boundary is the bank that is only capable of containing the daily flow and if the water rises above that bank it is flooding. In some cases, this may be true if there is only one bank. But if there are multiple banks in close proximity, is it still true?

An example of this argument is the claim that there are not regular freshes that occur six or eight times a year in Australia as stated in Kingdon v The River Hutt Board 1905, or even two or three times a year as suggested in Hallmann (2007, 13.65). Therefore, the daily low flow is all that is required to be considered.

Is the definition of a bank about the duration between freshes as the deciding factor? Or is it the fact that the channel can contain all the ordinary freshes that occur whenever that may be? This needs to be tempered with the same concept that applies to the Doctrine as explained in Humphrey v Burrell 1951. From the context of this case, it is clear that there must be a consideration of the way that rivers move, flow and behave in the location of the case being decided upon. The judge made clear that rivers in England move and behave by different processes to that of rivers in New Zealand as an example, and therefore what is acceptable change in one location may not be acceptable change in another location.

There are also semantic arguments about the function of the word ‘and’ in the definition of the bed in the Crown Land Management Act 2016. The common argument is that it is a limiting variable, therefore the surveyor finds the full bank capacity value and then finds the mean stage and places the boundary at that location. Therefore, arguing that both component parts of the definition are met. The meaning of ‘and’ is to connect phrases that are to be considered jointly, i.e. both must be satisfied in full; ‘and’ is not a limiting variable.

There are two significant problems with these arguments. The first is that they take the words out of context and apply some other meaning to them. The second is they are not defining a natural feature, i.e. there is nothing on the ground at these locations that is obvious and unmistakeable.

Furthermore, the definition in the Crown Lands Management Act 2016 is taken directly from the words in the case The State of Alabama v The State of Georgia 1859 and, as previously noted, this overturned Howard v Ingersoll 1851. Is it reasonable trying to interpret a definition that is the result of a case in 1859 by the words of the overturned case in 1851? This results in the definition meaning the outcome from 1851 and is in stark contrast to the intent of the hearing in 1859. The words need to be interpreted as they were intended by the case they are adopted from.

The holistic concept, as the courts have described it, is a simple and a common-sense approach that everyone can understand. Once the whole channel is full and there is nuance water flowing over the land, uncontained by any distinct natural feature, there is flooding, i.e. the water has left the container. This also must be tempered with where is the edge of the usable and ordinarily occupiable land. The point of flooding is variable like all other factors in water boundaries. No two sites are the same. There needs to be a common principle that everyone applies in the same way to achieve consistency and to define the natural feature that is observable and un-mistakeable on the ground. The top of the bank does not mean the top of the bank able to contain flooding. It is the bank that contains all the ordinary freshes.

5.2 The Application of the Doctrine of Accretion and Erosion

Throughout the surveying industry, there are many different understandings of how the Doctrine should be applied. The Registrar-General’s guidelines state (NSW LRS, 2023): “*Erosion – This is the natural and gradual retreat of the bank into the adjoining land caused by the action of a river or stream. The change in the position of the bank must only be discernible over a significant period of time not as a result of a sudden storm or flood.*”

This could be interpreted in three ways:

1) Lots of small changes un-noticeable in each flood event cause the overall long-term change and the land is eroded. Does the boundary move? Does this agree with the intent of the Doctrine?
2) A change that cuts a new path through the property, severing the land in a single event or in a series of events. During this change the river has not migrated across the landscape, but a new channel has been made. Does the boundary move? Does this comply with the Doctrine?

3) Any change caused by flooding does not comply with the Doctrine. Or put another way, if flooding can be proven to have occurred at any time, the change does not comply with the Doctrine and the boundary does not move. Does this outcome match the intent of the case law when read in context?

From Humphrey v Burrell 1951, the other interesting point to note is that the change failed as the change did not occur by accretion. The river carved a new channel, it did not move across the land in a continuous evolution of location eroding in front and accreting behind. There was further consideration that there is a considerable area ("this large area") of land that would change ownership as a result of an inequitable change.

The key message from Williams v Booth 1910 is on page 356, stating that it is not the sudden or gradual nature of the event which governs the law, but it is whether the change occurred by an imperceptible process.

Once the Doctrine has been considered and the boundary is determined, how does the surveyor convey all this information to those that are dealing with this matter? The current approach is to draw a plan and file the investigation in a filing cabinet. Is there a better approach?

6 REPORTS

One of the proposals being put forward is that every plan that defines a natural feature boundary must supply a report. This question was asked as part of the industry engagement process, and 92% of surveyors answering the question agreed that a report would be beneficial when re-defining that boundary. Interestingly, only 63% thought that a report should be a requirement.

The purpose of the report is a record of what was on the ground at the time of the survey and what feature the surveyor located in the survey as the boundary. The report is not intended to be a long or overly complicated document. The main beneficiary of these documents will be the next surveyor to survey that site or any subsequent surveyor.

A draft proforma report has been generated, which is 2-3 pages long:

- Page 1 includes information about the site:
  - River particulars, including name.
  - Title particulars.
  - Date of the Crown grant.
  - Is the title tidal or non-tidal?
  - Are there any 100-foot reserves or fixed-width reserves?
  - Could Ad Medium Filum Aquae apply?
  - Followed by a half-page size image.
- Page 2 includes:
  - A list of questions (14) about the Doctrine to assist the surveyor in deciding if any change has occurred, whether the change complies with the Doctrine and why.
  - Each question only requires a one-sentence answer.
  - Followed by a third-page size image.
- Page 3 includes:
  - More images.
  - Extracts from the search of important information.

The aim of the report is transparency and consistency. By making reports compulsory, it is a fair and equitable outcome, and everyone is required to produce a report. So next time you get a plan surveyed after 2023, there will be some images of the site as it was, and you will know exactly what feature the last survey adopted and why. All this will be available before you leave the office, even if there was no change to the boundary.

7 CONCLUDING REMARKS

Before navigating water boundaries, one must undertake a voyage of discovery through the annals of the courts. Open the mind, leave the preconceived and bias beliefs behind and consider the original words and concepts as a whole within the context they were written.

At first glance, water boundaries appear to be very confused and full of rules that appear to contradict depending on the circumstance applied. However, if the documents are read in full, the context understood and taken at face value without applying any modern slant, the majority agree. If, at first, they do not appear to agree, reconsider the intent of the concept described by the words with less emphasis on the individual words themselves. There will always be cases where one judge disagrees about a point here or there, but in general they all agree. If any do not, it will be obvious that the judge did not consider the context but tried to apply a meaning of a word or phrase in isolation or has taken the words completely out of context.

The role of the Office of the Surveyor-General is not to provide legal advice but to provide guidance, hence each surveyor must make up their own mind. The draft of the updated Surveyor-General's Direction No. 6 (Water as a Boundary) has been written according to the principles described in this paper. A key decision made early in this review was that all documents researched will have been interpreted in context and the integrity of the Torrens titling system held in the highest regard.

Context, ethics and transparency are the three most important things when it comes to natural boundaries. Without these the system is in constant tension and surveyors are constantly trying to justify why their plan is different to the last, even though nothing has really changed to any substantial degree.

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Electrical Safety and Recent Incident Summary

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ABSTRACT

Subsurface utility assets are generally hidden from view and may be located just below the surface. If such assets are breached, this can cause serious Work Health and Safety (WHS) issues for surveyors and disrupt essential services for the surrounding community. For example, a recent incident involved a surveyor striking a 11 kV cable along a major roadway with a timber boundary peg, resulting in an arc flash (light and heat generated from an electrical explosion where electricity suddenly travels through the air from one point to another) and a large-scale power outage to more than 2,000 people. Aiming to prevent the occurrence of such incidents, this presentation discusses electrical safety, industry trends and incidents, lessons learnt from recent cable impacts and safety advice regarding the planning of work and safety around electrical infrastructure.

KEYWORDS: *WHS, electricity, electrical safety, arc flash, look up and live.*

Endeavour Energy

Endeavour Energy Network Coverage

Our network spans 24,800 square kms and is made up of more than 185 major substations, 416,000 power poles and 32,000 smaller substations connected by 47,000 kms (more than the distance from Sydney to London and back) of underground and overhead cables.

Endeavour Energy services the high growth regions of NSW, with the population of Greater Western Sydney forecast to grow approximately by almost one million people by 2031.

Our franchise area includes the North West and South West priority growth areas of Sydney which will see 500,000 new residents over 30 years.

These priority growth areas are the result of the biggest coordinated land release in NSW's history.

Endeavour Energy

Urban Expansion

Western Sydney and other surrounding areas within Endeavour Energy's franchise area are undergoing major infrastructure development, asset relocation and urban expansion as a result of increased government funding and the establishment of the new Western Sydney Airport.

Despite ongoing public safety initiatives and awareness campaigns, there is an increased trend that can be observed in overhead and underground asset strikes.

Endeavour Energy's statistics are directly related to the higher volume of worker activity within our franchise area.

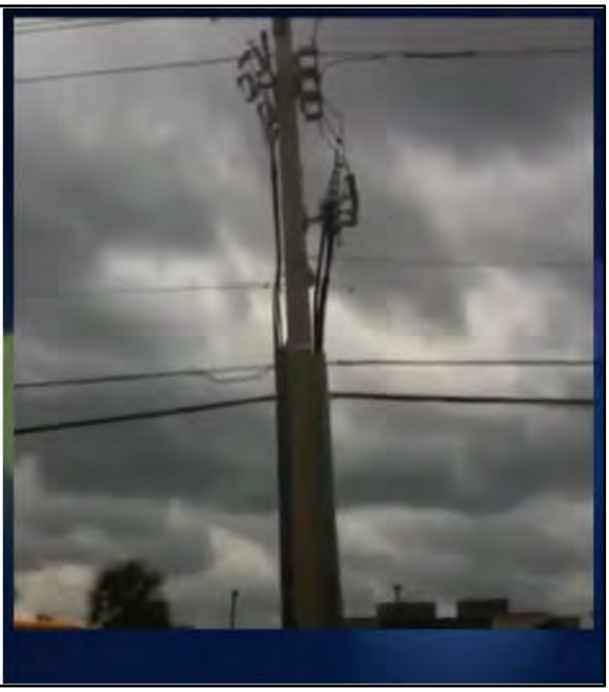
Endeavour Energy

Cable Strikes

Last year Endeavour Energy reported 53 underground cable strikes.

- 52 plant/equipment strikes
- 1 handheld tool strike

This literally equates to an event every week that had the potential to cause death and/or serious injury.



Endeavour Energy

Cable Strikes

Recently a surveyor struck an 11kV cable wit a timber boundary peg resulting in an arc flash and large-scale outage to over 2000 people.

The cable was entering a utility access channel in a bridge overpass. Workers are reminded that underground assets may be congested at the approach to bridges and other structures.

Typical asset depths and alignment may vary substantially, rising and falling sharply and at much shallower depths than elsewhere as they are channelled into shared allocated spaces on bridges and other structures.

Endeavour Energy

Cable Strikes

Two tradies suffer horrific injuries after hitting underground electrical cables with heavy machinery on a Sydney work site – *April 24, 2020 - Eastern Creek Western Sydney*

Following a strike to an 11kV cable with a reciprocating saw, an arc flash occurred igniting an adjacent low pressure gas main engulfing the entire trench in flames.

- **Workers were rushed to hospital after being injured at a Sydney work site**
- **A man 36, is lucky to be alive after suffering severe neck and face burns**
- **NSW Ambulance says facial burns can be life threatening if not treated quickly**

By LOUISE AYLING FOR DAILY MAIL AUSTRALIA
PUBLISHED: 13:55 AEDT, 24 April 2020 | **UPDATED:** 17:19 AEDT, 24 April 2020

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Two workers are lucky to be alive after hitting underground electrical cables with heavy machinery during a work site accident in Sydney's western suburbs.

Two men were injured after their excavator hit an electrical main at the site on Honeycomb Drive at Eastern Creek at about 10.55am on Friday morning.

One of the men, 36, suffered serious neck and facial burns while a man in his late 20s received minor facial burns.

© Nine News

Endeavour Energy

Overhead Strikes

Last year Endeavour Energy reported 224 OH conductor strikes.

- 121 High Load Traffic strikes
- 14 Agricultural related strikes
- 26 Construction related strikes
- 63 Relating to general plant movement

This almost equates to an event every weekday that had the potential to cause death and/or serious injury.

Endeavour Energy

Overhead Strikes

Fatality - *November 14, 2014 – Marsden Park Western Sydney*

"A truck driver was found dead after his vehicle hit power lines in Sydney's west this morning.

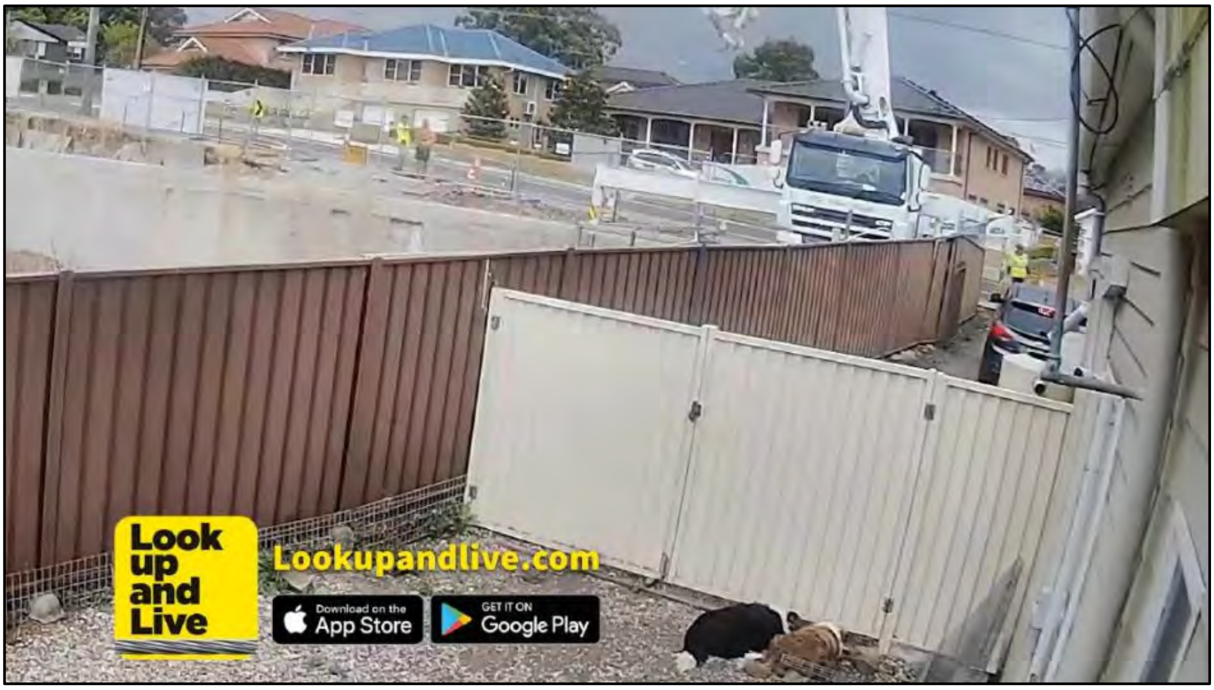
A nearby resident reported the truck had been abandoned however police arrived to find the truck driver dead on the ground beside it on Richmond Rd, Marsden Park about 5am"

Endeavour Energy

Emerging risk area – concrete boom trucks

With the high volume of construction activity and increased use of concrete pumping cranes, we are observing a rising trend in related incidents.

In the past 6 months there have been at least 4 incidents involving contact with high voltage powerlines, one resulting in significant permanent injury.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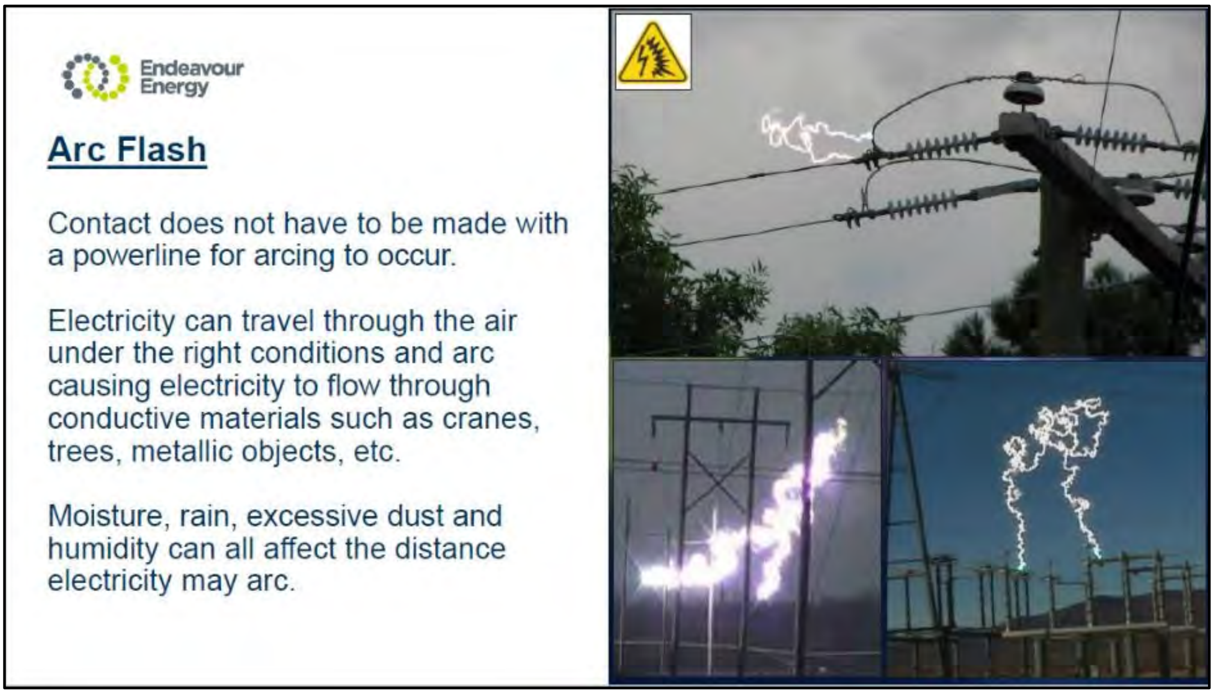
Endeavour Energy
Arc Flash
Contact does not have to be made with a powerline for arcing to occur.
Electricity can travel through the air under the right conditions and arc causing electricity to flow through conductive materials such as cranes, trees, metallic objects, etc.
Moisture, rain, excessive dust and humidity can all affect the distance electricity may arc.

Endeavour Energy

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Endeavour Energy

Fallen Powerlines

Fallen powerlines can be deadly.

They can be damaged by fallen trees, lightning strikes, car accidents, vandalism, fires, birds or other animals and flying debris during high winds.

Never approach fallen powerlines. Keep at least eight metres away from them and anything they may be touching such as trees and fences as there may be a risk of touch or step potential voltage.

Stay, Call and Wait

Endeavour Energy

Fallen Powerlines

Electricity will travel through the ground trying to return to its source of supply.

Often fallen powerlines remain energised but people may incorrectly assume the power is off and attempt to touch the conductor..

This creates a risk known as 'step potential' where the closer you get to a fallen conductor, the higher the potential voltage a person may be exposed to.

Look up and Live

Incidents & Emergencies

UNDERSTANDING STEP & TOUCH POTENTIAL

Endeavour Energy

Fallen Powerlines

Fallen powerlines can have severe consequences.

In early 2022 a fallen high voltage powerline in a paddock on the Wollongong south coast killed 8 cows.

Lucky there was no impact to human life however; the situation demonstrated how serious the risk of fallen powerlines can be.

What to do if your vehicle brings down powerlines

Endeavour Energy

Electrical Injuries

The impact of an electrical incident can be life changing.

Not only does an electric shock have the potential to result in death, but the injuries also sustained can be horrendous.

These injuries can result in serious burns, lost limbs and permanent impairment through high energy arc flash and heat generated.

Endeavour Energy

Arc Flash Injuries

An Arc flash is the light and heat generated from an electrical explosion. It is generally an unexpected and violent, electrical short circuit in the air that produces an arc and associated explosions of gases and molten metal.

Temperatures of an arc flash are estimated to be in excess of 30,000°C which is six times hotter than the surface of the sun (~5000°C).

These extreme temperatures ignite clothing, melt metal and cause blindness from the intense light.

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Arc Flash Injuries

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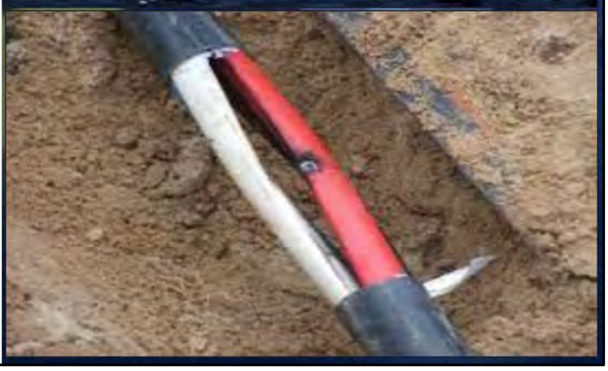
Endeavour Energy

Community Impact

Every time there is an impact to the power supply, communities are left without power for extended periods of time.

When the power is cut off unexpectedly, many services are impacted including:

- Life support and medical equipment
- Air-conditioning (heating/cooling)
- Refrigeration
- Business impact / working from home
- Internet and phone services
- Traffic light outages



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Planning/Preparation is critical!

Ensure you are familiar with the site and comprehensively inspect the areas.

Understand any plant/equipment limitations, movements and mobilisation across the site.

Obtain contact details for asset owners and follow all safe work practices and guidance.

Look UP and check for powerlines

Look DOWN and search for markings, assets, evidence of trenching, pits, covers, etc.

Endeavour Energy

Planning/Preparation is critical!

Engage competent locator services to identify existing services and mark out the site. Ensure current and accurate maps and drawings are obtained, understood and available for site personnel and planners of work.

Never attempt to touch or access electrical assets and equipment, please contact Endeavour Energy for advice and further support onsite.

Following the Five Ps of Safe Excavation guidelines can ensure the right steps are taken:

- *Plan*
- *Prepare*
- *Pothole (by hand!)*
- *Protect*
- *Proceed*

Endeavour Energy

Before You Dig Australia

The most effective way to prevent an incident is to be prepared for the site conditions and have the relevant site drawings.

Before penetrating the ground, understand what may be underneath you.

Just because you can't see anything, doesn't mean it isn't there!

Across Endeavour Energy's network there are over **16,000kms** of underground cables.

We partner with BYDA and share their core vision to prevent injury and reduce damage to our members' infrastructure assets.

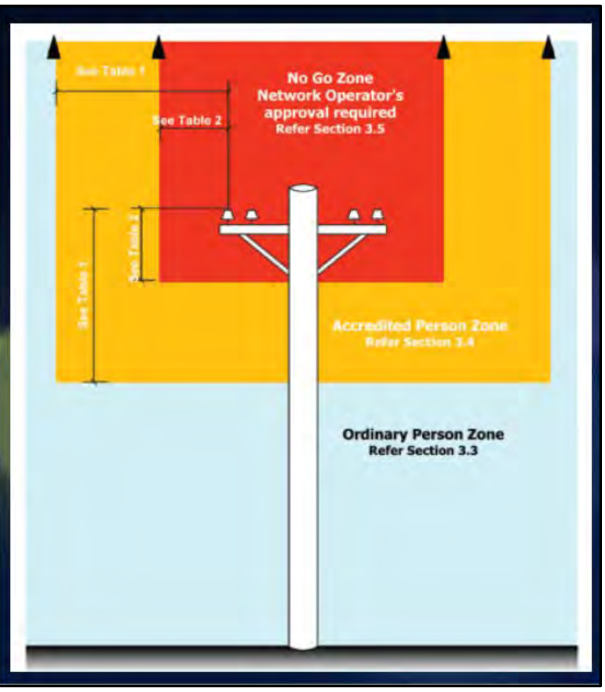
Endeavour Energy

Safe Approach Distance

When planning or performing work near overhead powerlines, it is important to apply the appropriate exclusion zone for the voltage concerned as defined in the *Safe Work 'Work Near Overhead Powerlines' Code of Practice*.

General rule is at least 3m from any powerline

This 'line to sky' exclusion area applies to all construction related activity such as operation of cranes and equipment (including the movement of loads over powerlines).



Endeavour Energy

Exclusion Zones

Shown right is a site in Wollongong where a tower crane lost control in strong winds and contacted 11kV.

This incident caused a large-scale outage, significant damage to the powerlines and existing property as the clash caused an intermix where high voltage mixed with low voltage impacting multiple customer installations.

The company was prosecuted.

Endeavour Energy

Exclusion Zones

Shown right is an incident site where a public worker constructing a large steel structure extended a small mobile EWP carrying a steel purling outside the building envelope contacting 132kV.

Luckily, the current passed through the steel purling and to earth via the EWP rather than through the worker avoiding an electrical shock or any arc flash burns.

Endeavour Energy

Bunting / Flagging Controls

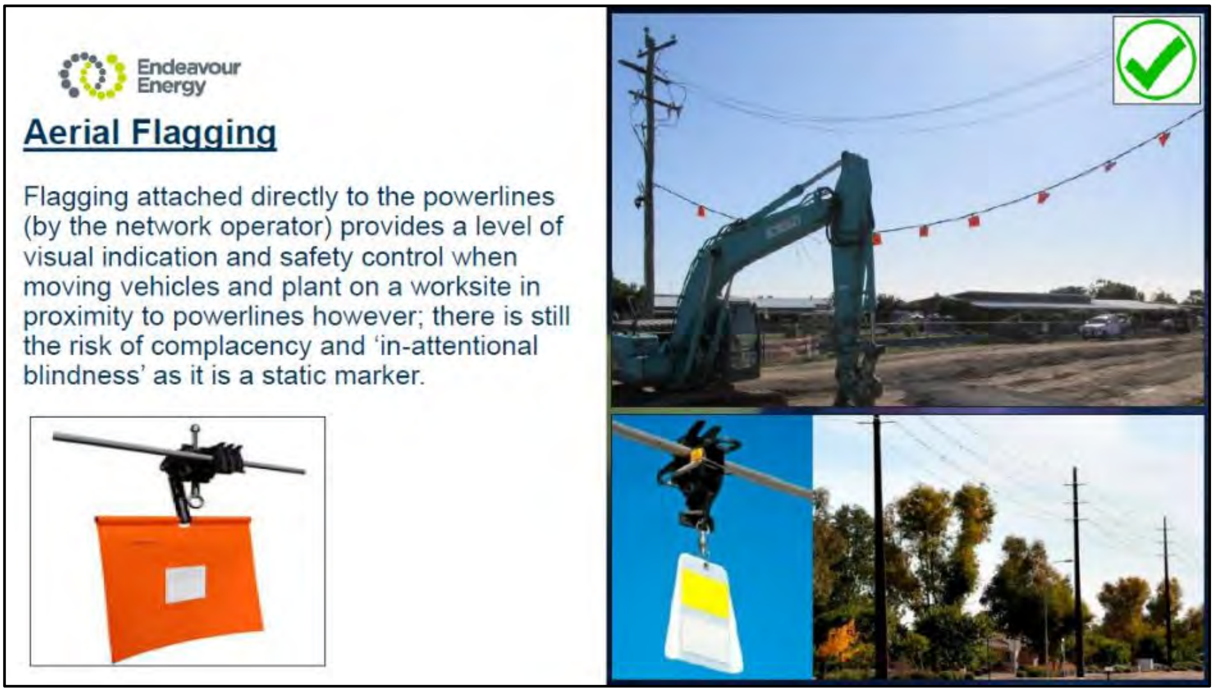
Often on large scale projects involving infrastructure development and asset relocations, heavy use if signage is employed with flagging/bunting installed to indicate maximum vehicle and plant operating heights.

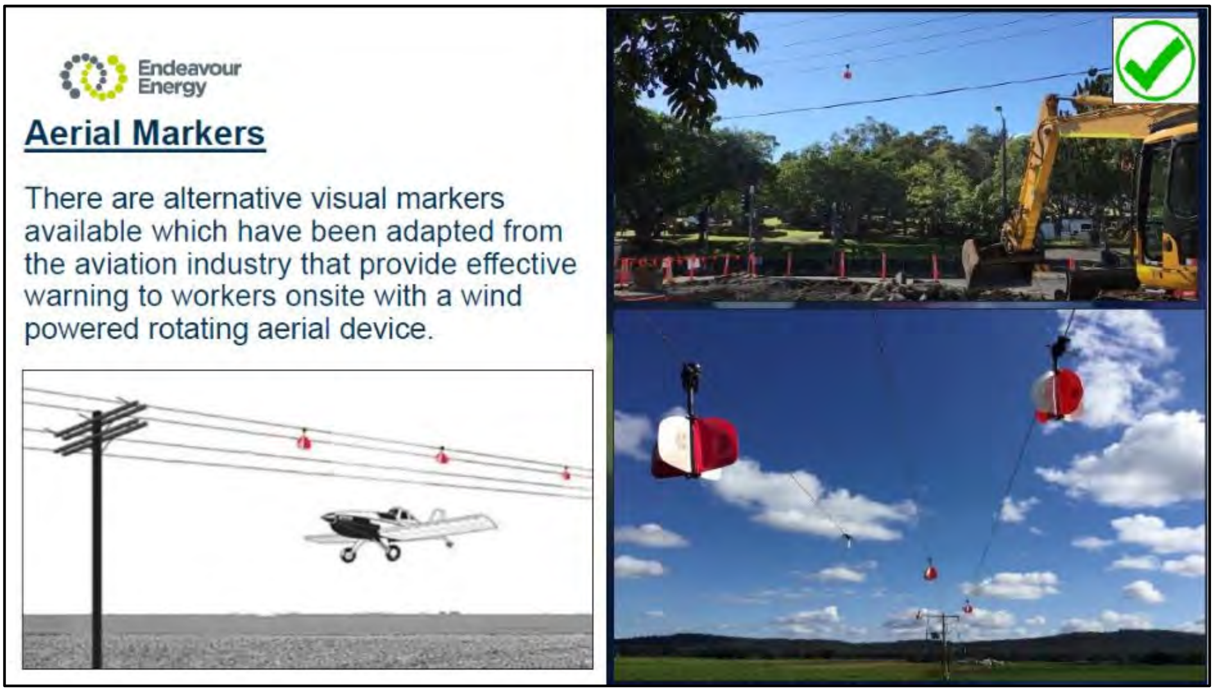
Whilst this type of control is a great demonstration of effective planning and preparation, the bunting often requires ongoing maintenance and workers become passive to its existence.

Endeavour Energy

Tiger Tails and Mats

Upon request, network operators may apply visual markers and indicators to assist identification on construction sites however; these types of covers are not to be confused with temporary insulation – *they are for visual indication only.*


Endeavour Energy
Aerial Flagging
Flagging attached directly to the powerlines (by the network operator) provides a level of visual indication and safety control when moving vehicles and plant on a worksite in proximity to powerlines however; there is still the risk of complacency and 'in-attentional blindness' as it is a static marker.


Endeavour Energy
Aerial Markers
There are alternative visual markers available which have been adapted from the aviation industry that provide effective warning to workers onsite with a wind powered rotating aerial device.

Endeavour Energy

Aerial Markers

A mix of tiger tails, bunting, signage and rota-markers can be used and effectively draws attention to the overhead powerlines.

Energy QLD have reported a large uptake in the installation of these markers and a significant reduction in overhead powerline strikes.

These markers are available in NSW and will become more commonly used on construction and agricultural sites.

Endeavour Energy

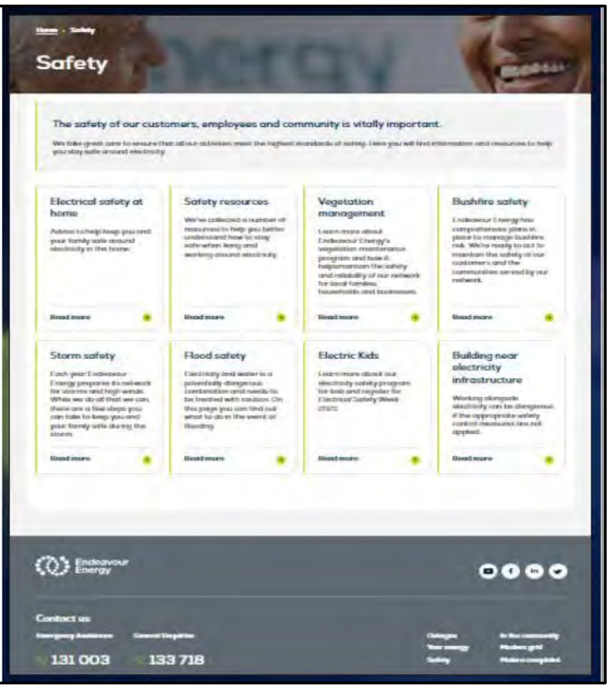
Further advice

Endeavour Energy offers guidance and advice regarding construction and work near our assets, please visit our website for a range of resources and information: https://www.endeavourenergy.com.au/

For specific advice relating to construction near Endeavour Energy's network, complete a *request for safety advice* and send it to:

construction.works@endeavourenergy.com.au

For an emergency, please call Endeavour Energy on 131 003 immediately.



Endeavour Energy

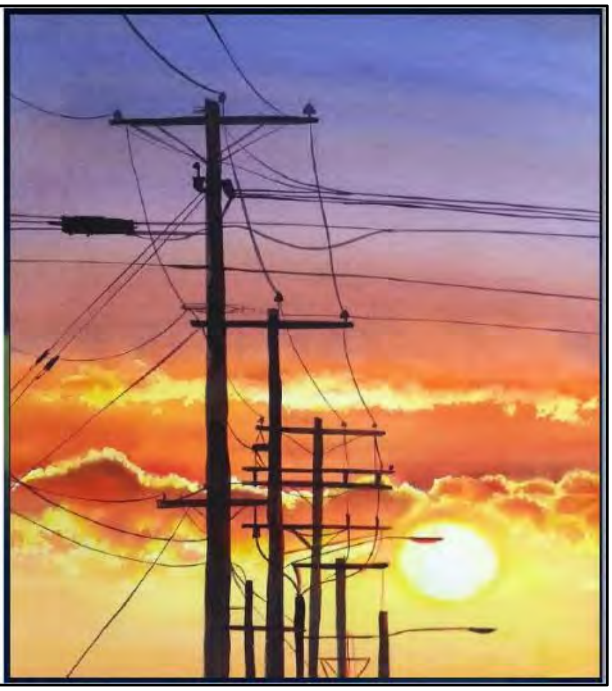
Inattentional Blindness

Powerlines are designed and constructed with the intention of being out of common sight and to blend in with surroundings.

They can be difficult to spot and can be missed if not carefully inspected, particularly if you are distracted.

It is a genuine human factor - It is hard to see what you are not looking for!

Pre-planning is key!



Endeavour Energy

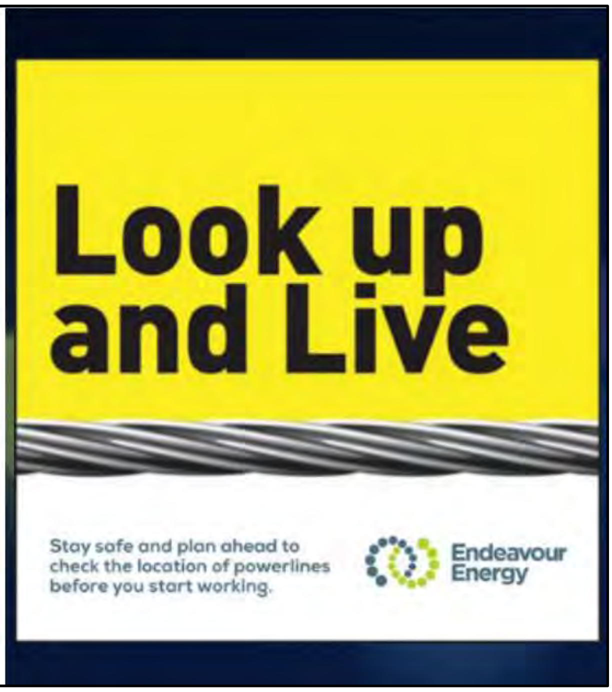
Look Up and Live

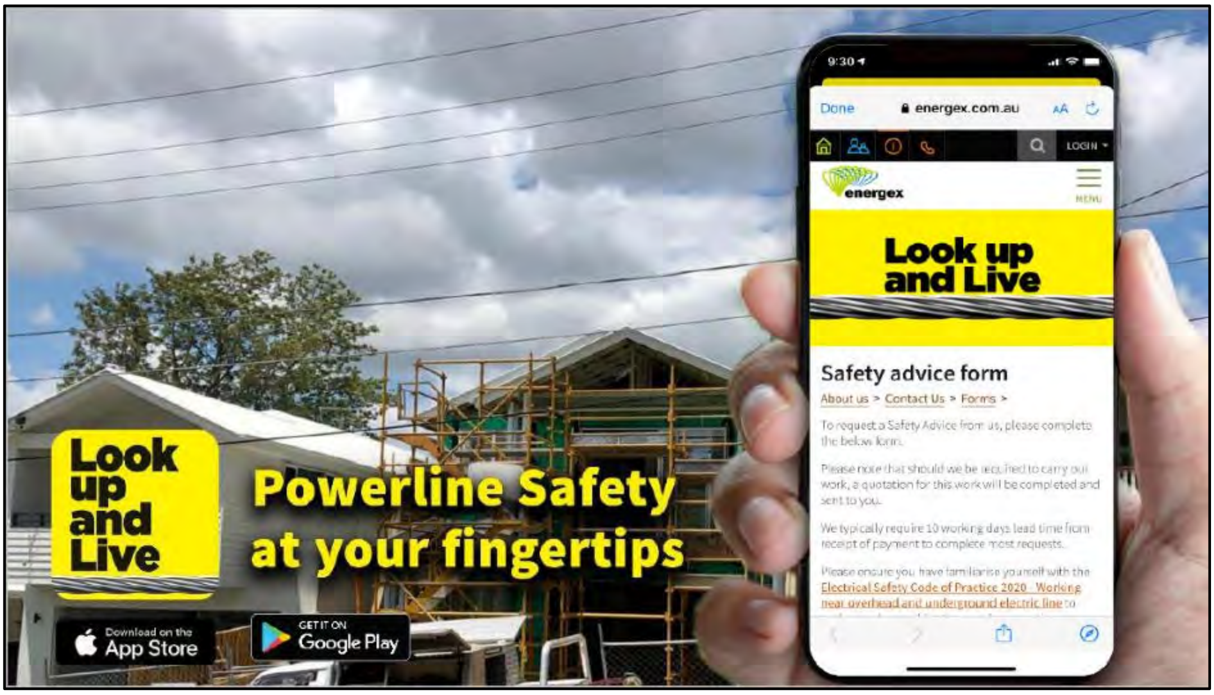
The most effective way to prevent an incident is to be prepared for the site conditions.

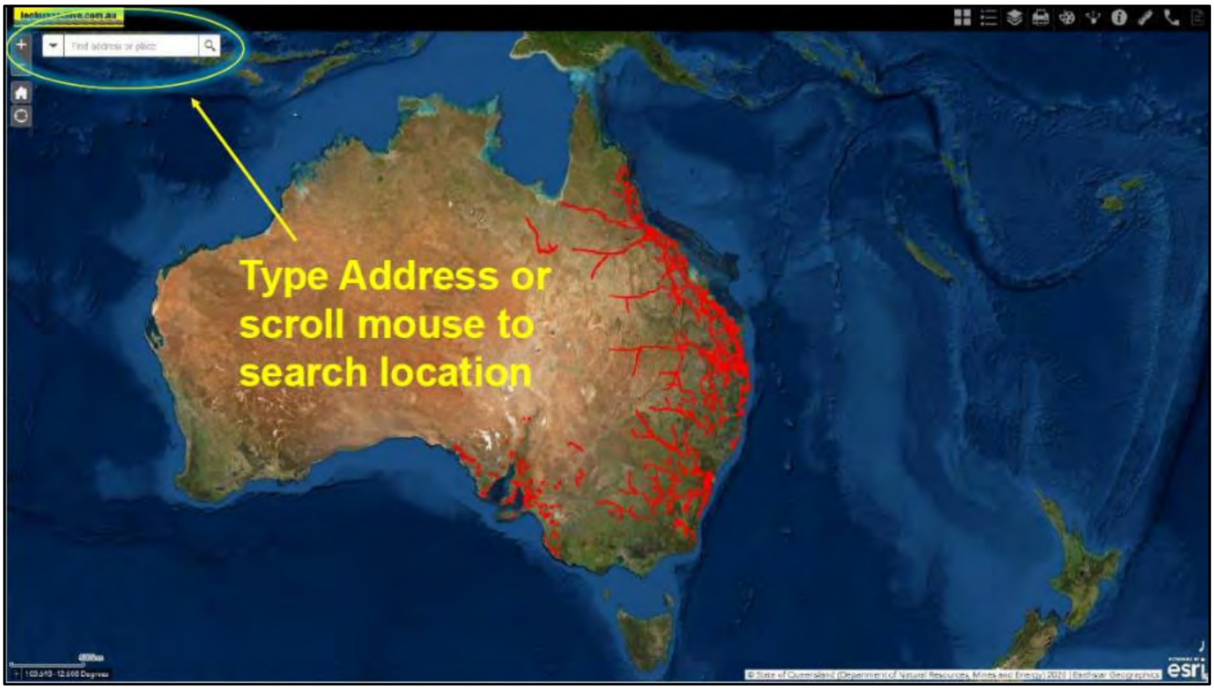
Before mobilising to site and operating plant or equipment, take the time to look up and inspect for powerlines and other overhead services.

Ensure you are familiar with the operating heights of your machinery, assess travel routes and know the safe approach distance to powerlines.

We have partnered with the creators of 'Look Up And Live' (Energy QLD) and other Electricity Utilities by providing access to our Powerline network data for customers to be able to utilise the Powerline safety planning tool.




Look up and Live
Powerline Safety
at your fingertips
Download on the App Store
GET IT ON Google Play
energex.com.au
energex
Look up and Live
Safety advice form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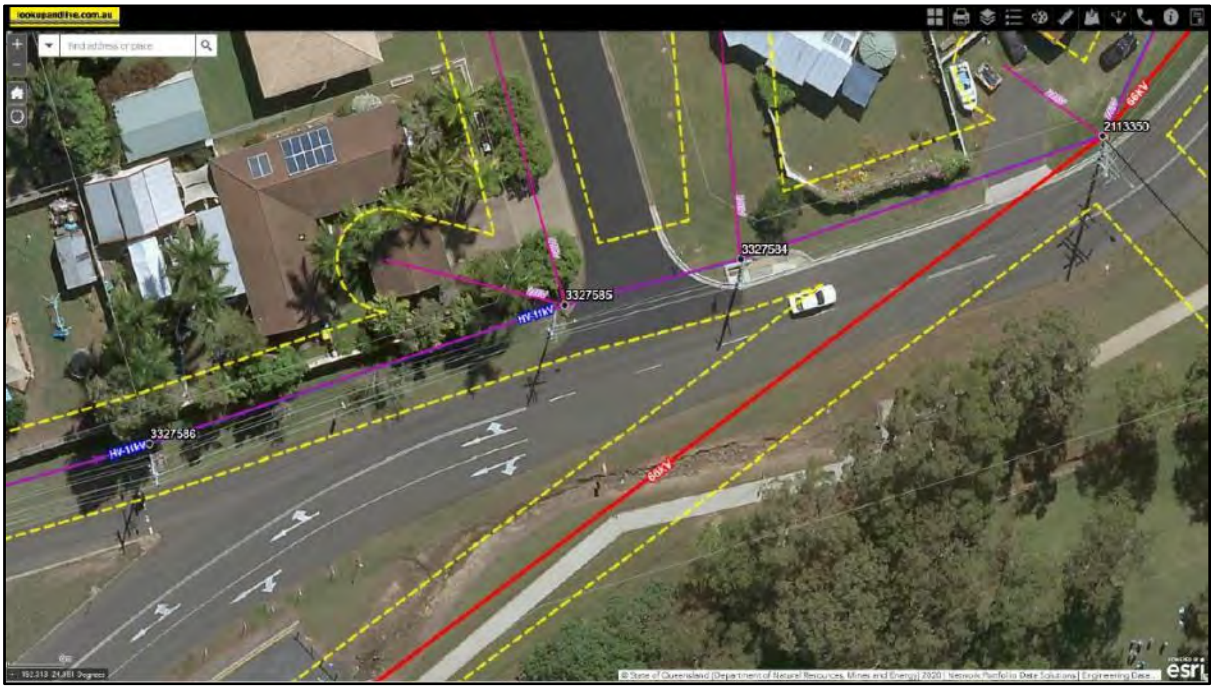
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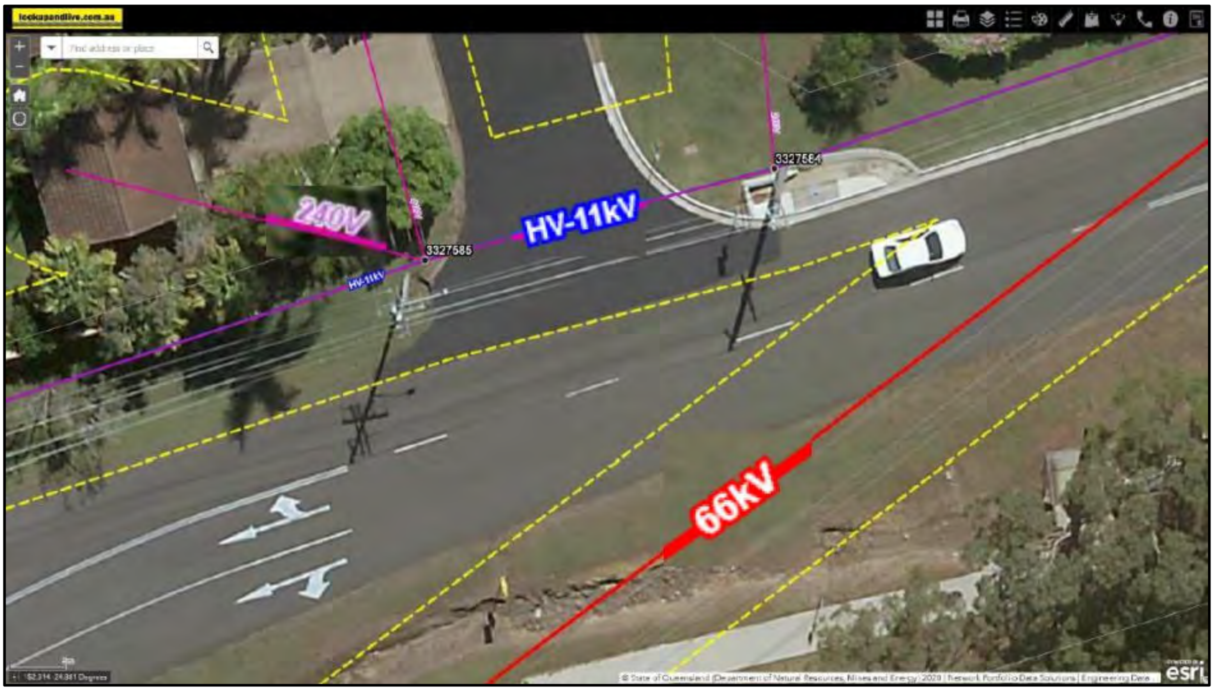
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Click on powerline to see more information
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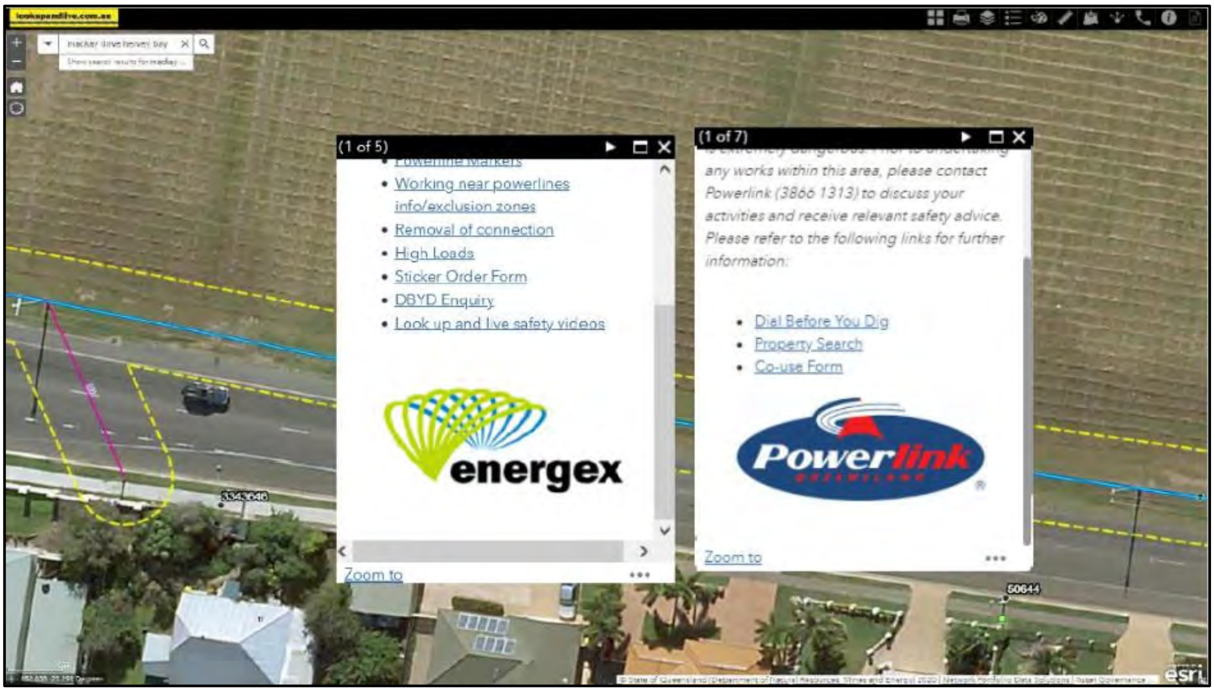
(1 of 5)
• Working near powerlines info/exclusion zones
• Removal of connection
• High Loads
• Sticker Order Form
• DBYD Enquiry
• Look up and live safety videos
energex
Zoom to
(1 of 7)
any works within this area, please contact Powerlink (3866 1313) to discuss your activities and receive relevant safety advice. Please refer to the following links for further information:
• Dial Before You Dig
• Property Search
• Co-use Form
Powerlink
Zoom to
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Click to get property information


HIGH RISK AREAS


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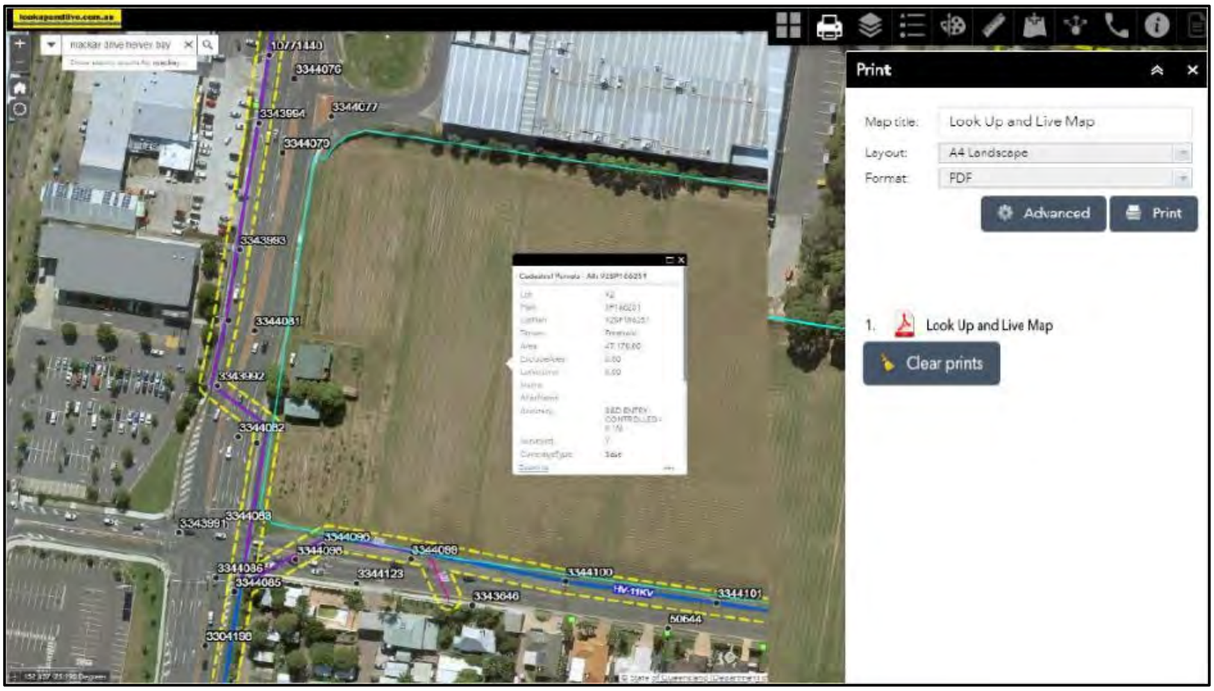
HV-11KV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Look Up and Live Map
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LV Overhead Network
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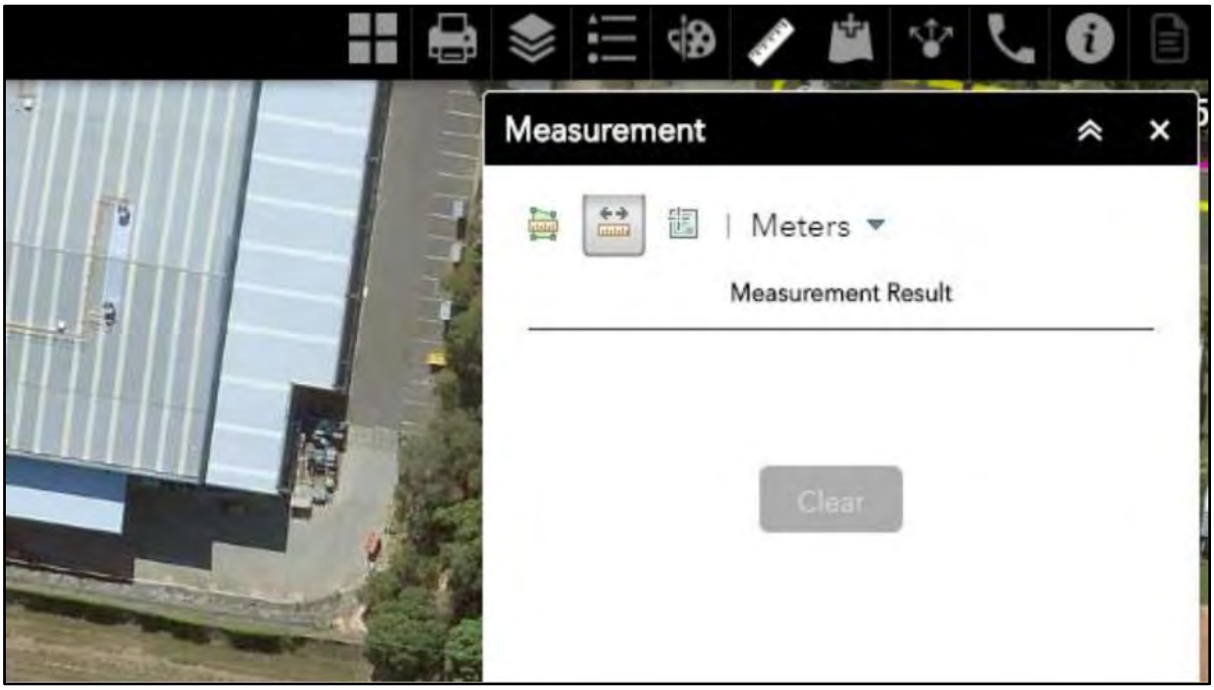
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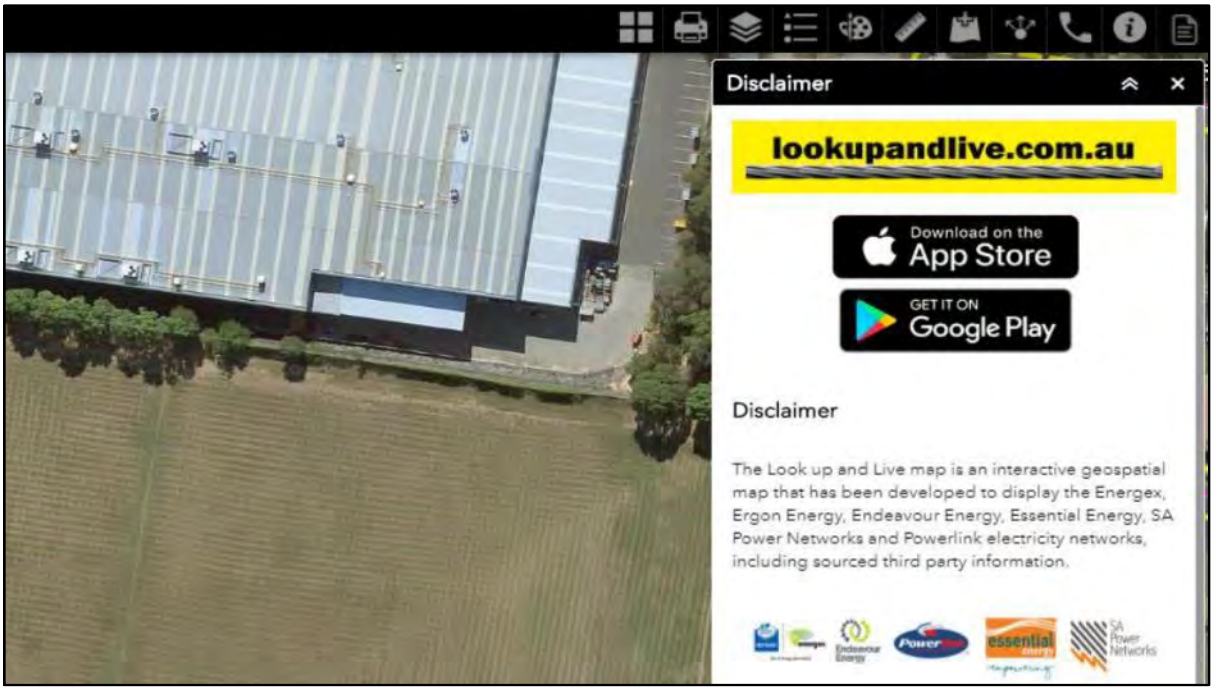
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The Look up and Live map is an interactive geospatial map that has been developed to display the Energex, Ergon Energy, Endeavour Energy, Essential Energy, SA Power Networks and Powerlink electricity networks, including sourced third party information.

Digital WHS: Integrated and Automated Workflow

Stephen Saunders
Transport for NSW
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ABSTRACT

Inspired by a paper presented at the APAS Webinar Series 2021, where Stewart Folley outlined the development of a new Work Health and Safety (WHS) system for DCS Spatial Services Survey Operations, this presentation discusses a similar journey and process that evolved at Transport for NSW (TfNSW) Survey Services throughout 2021 and 2022. A safety review found our current WHS documentation to be outdated and non-compliant in several areas. The documentation was largely paper-based, interpreted and used differently from unit to unit, poorly engaged with by staff, and not fit for purpose or specific to the work site. The current Safe Work Method Statement (SWMS) documentation was a major source of concern, with complex and long-winded paper documents containing any possible hazard that could be thought of and a raft of safety controls that were either not actual controls or could not possibly be implemented on a site. Despite the safety-focused practices of staff, the system and the documentation did not support their efforts. The Survey Practice unit set about overhauling the current system with a focus on compliance, ease of use, accessibility and an ability of the system to generate reporting metrics and collect feedback so management could perform analysis and gain an understanding of where improvements could be made to increase staff safety and engagement. This presentation discusses the development of a Risk Register, site-specific SWMS, Traffic Guidance Schemes (TGS) and how all these procedures and documents were integrated into a digital platform that can be easily accessed in the field on a mobile device. Noting that there are numerous digital systems available on the commercial market, TfNSW adopted the philosophy of developing an in-house system by our surveyors for our surveyors that focused on the safety issues and risks that were important to our team members and managers. Funding for the development of the digital platform was conditional on the system being scalable to a branch level, where other teams who undertake field activities (such as Bridge Inspectors and Geotech) could leverage off the same workflow yet tailor content to their own requirements, so that throughout the branch a consistent approach to safe work procedures could be adopted.

KEYWORDS: *WHS, digital, TfNSW, site-specific SWMS, risk register, traffic guidance scheme.*

Proceedings of the 26th Association of Public Authority Surveyors Conference (APAS2023)
Coffs Harbour, New South Wales, Australia, 20-22 March 2023

Agility, Ability and the Human Side of Surveying When Disaster Strikes

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ABSTRACT

Flooding in late February, March and early April of 2022 caused significant damage along large sections of the Australian east coast, in particular locations within the Northern Rivers of NSW. Only days preceding the peak of the first flood event in early March, the NSW State Emergency Service (SES) reached out to NSW Public Works to devise a strategy to engage and brief surveyors for capture of Peak Water Level (PWL) as a priority and Current Water Level (CWL) to a lesser degree for SES flood intelligence, as soon as possible. Several DCS Spatial Services and local private surveyors utilised Global Navigation Satellite System (GNSS) Continuously Operating Reference Station (CORS) Real-Time Kinematic (RTK) across defined areas within the Clarence Valley, Richmond Valley, Lismore and Kyogle Local Government Areas (LGAs) where reliable evidence defined PWL, recording Australian Height Datum (AHD) height, photos, notation of physical evidence and location on SES intelligence maps via the ArcGIS Collector application. A subsequent severe weather event, which hit Byron Shire in late March 2022, required DCS Spatial Services surveyors to continue further PWL intelligence gathering for SES and Byron Shire Council at key hydrology and flood affected locations. Overall, the survey project captured 651 PWLs and 27 CWLs across five LGAs in just over a month, with a capture rate of more than 85% on specifically requested locations. However, this paper discusses more than the survey technique, project outcomes, statistics and lessons learnt. It tells a story of grieving and healing, resilience, power of community after a natural disaster, and the delicate situation the surveyors found themselves in when capturing this much-needed data during this time. This project will serve to enhance future planning of SES emergency response, understand deficiencies and 'pinch-points' in local infrastructure, and improve agility to provide survey resources in case of future severe weather events.

KEYWORDS: *Flooding, emergency response, intelligence, resilience, empathy, agility.*

1 INTRODUCTION

Public authority surveyors have been, and expectantly will continue to be, the public's first physical contact in the field when planning or executing surveys for state-government-funded infrastructure projects, public space or Crown land adjustments, environmental projects and state survey infrastructure or mapping projects, to name a few. Often, being in the field on these projects, some of which are contentious, will be at a time when public emotions are ‘raw’ and tensions are high. Interactions with the public can be challenging, confronting and intimidating. From one of the author’s many years of experience in the field, misinformation, lack of information and/or fear of the ‘unknown’ can contribute to the above. This presents an opportunity to empathise, inform, prepare and enlighten the affected public. Realistically, not all the disaffected public will ‘receive’ the public surveyor well. However, being a public servant, we must all attempt to build understanding and repour, even if that takes a little more time than we would like.

The NSW State Emergency Service (SES) flood intelligence gathering project in late February, March and early April of 2022, following the devastating historical Northern NSW weather events, was one such project that revealed all the above. The agility of public authority surveyors who collaborated to plan and execute this project on behalf of the SES Intelligence Gathering team, as soon as access allowed and augmented with a human touch on the ground, transpired into a well-received NSW government agency initiative that was humbling, inspiring and rewarding for those involved, and which provides a template for future disaster responses.

This paper not only discusses the surveying technique, project outcomes, statistics and lessons learnt from this project. It also tells a story of grieving and healing, resilience, power of community after a natural disaster, and the delicate situation the surveyors found themselves in when capturing the much-needed data during this challenging time.

2 FEBRUARY & MARCH 2022 WEATHER EVENTS IN SOUTHEAST QUEENSLAND AND NORTH-EASTERN NSW

Following two years of La Niña conditions (BOM, 2022a), catchments in southeast Queensland and north-eastern NSW were already saturated. There was above average rainfall 4-5 months preceding the severe weather events in late February and March 2022 (Figures 1 & 2), causing down-river towns and villages to be susceptible to flooding at any time if an ‘east-coast low’ were to form and persist over these catchments.

As shown in Figure 1, the cumulative rainfall exceeded the 90th percentile at the Alderley rain gauge. East Coast Lows (ECLs) coming out of southeast Queensland have a profound effect on north-eastern NSW catchments, due to their size and proximity to southeast Queensland just across the border. As ECLs have a natural tendency to move in a southerly direction, the northern extents of the Clarence River, Richmond/Wilsons River, Tweed River and the smaller Brunswick River and Marshalls Creek catchments are collecting large volumes of precipitation prior to an ECLs reaching major north-eastern NSW towns (Figure 3).

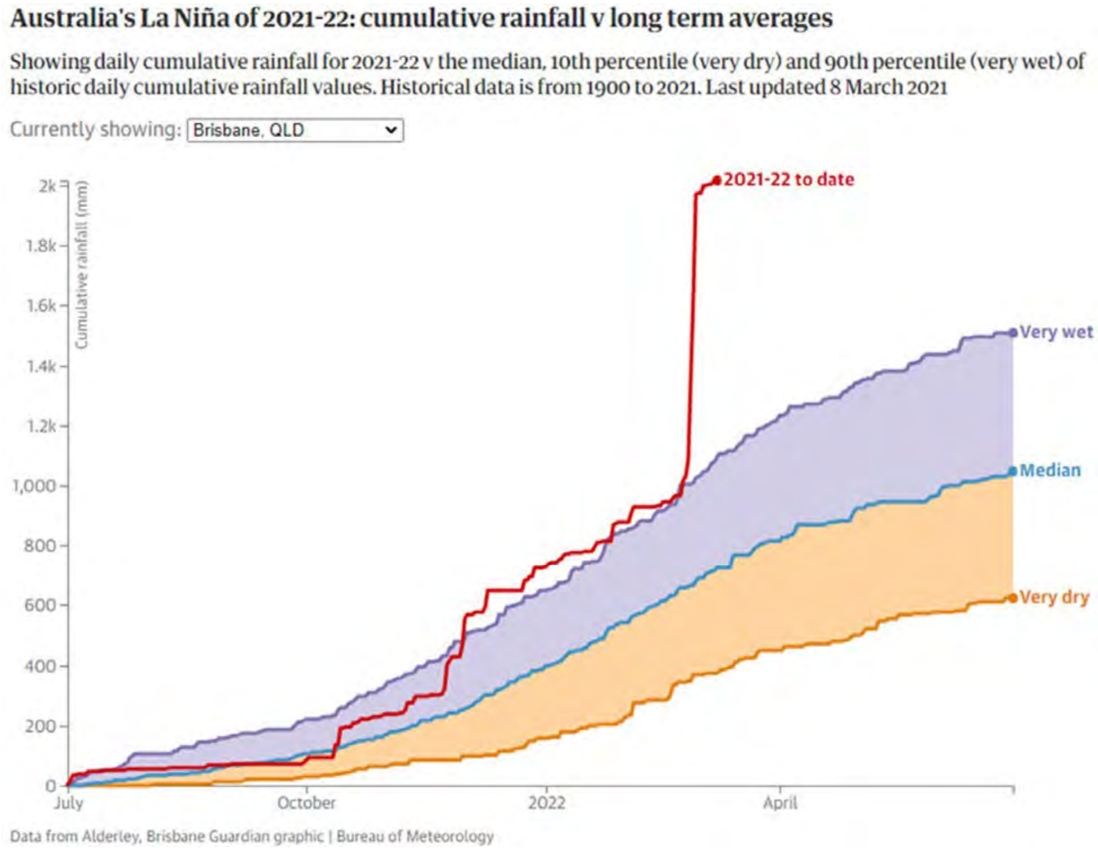

Figure 1: Brisbane cumulative rainfall vs. long-term averages to 08/03/2022 (Evershed and Nicholas, 2022).

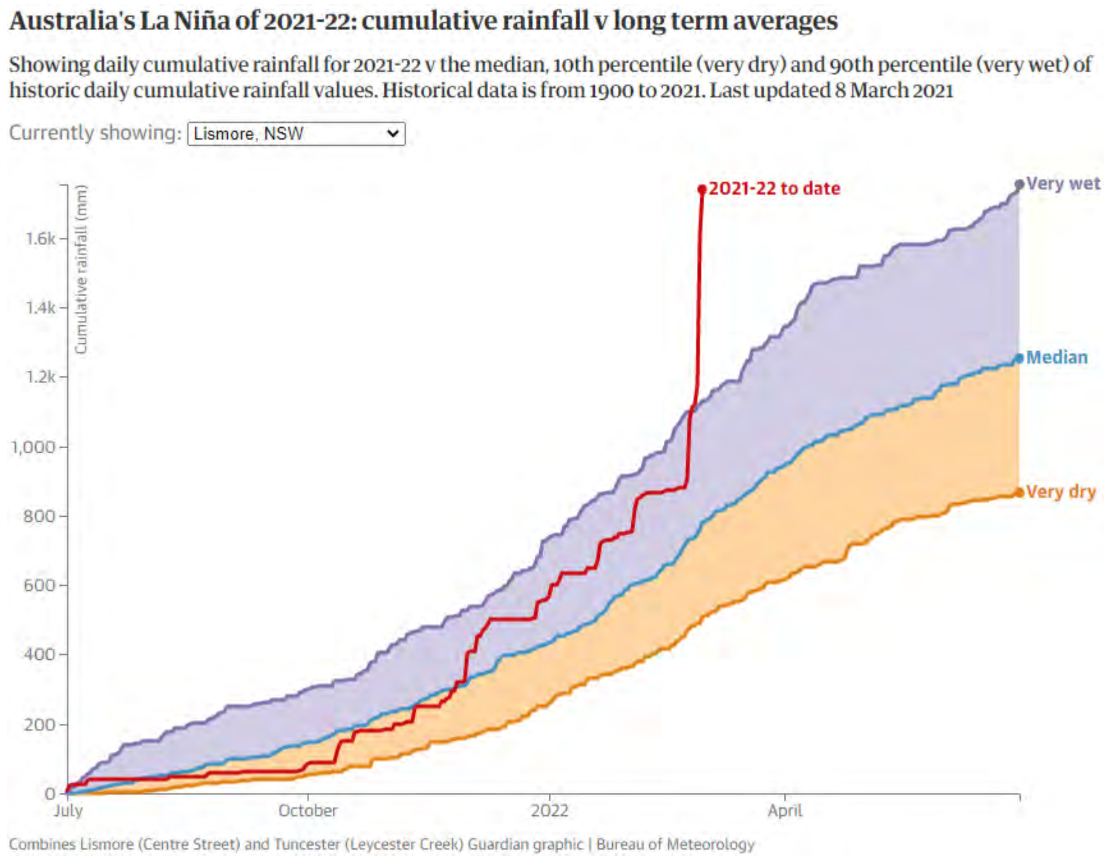

Figure 2: Lismore cumulative rainfall vs. long-term averages to 08/03/2022 (Evershed and Nicholas, 2022).

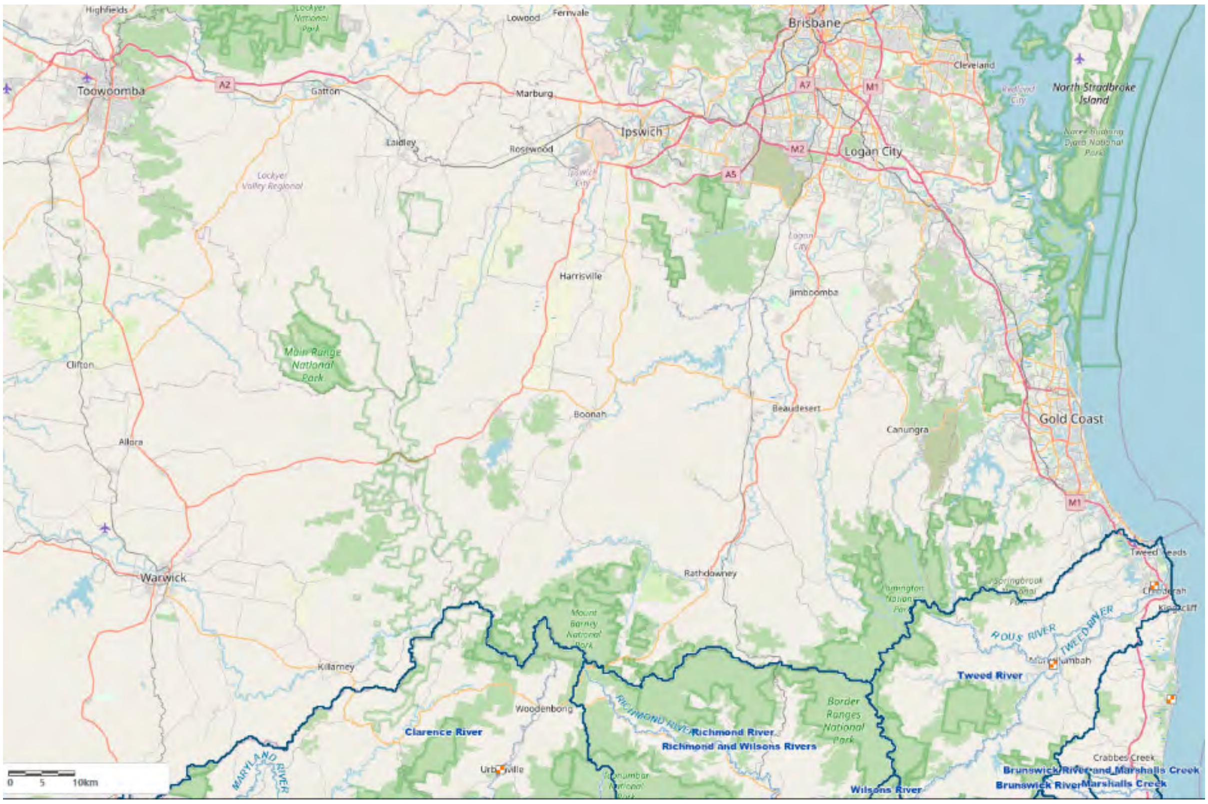

Figure 3: River catchments shown in dark blue (NSW SES GEM mapping).

As such, already saturated catchments and the catchments being pre-primed in their upper reaches, combined with well-above 'localised' rainfall within major Northern River towns, villages and localities (Figure 4), leading to some of the worst flooding on record. Figure 5 shows only one example from Lismore – others can be found in Bath (2022).

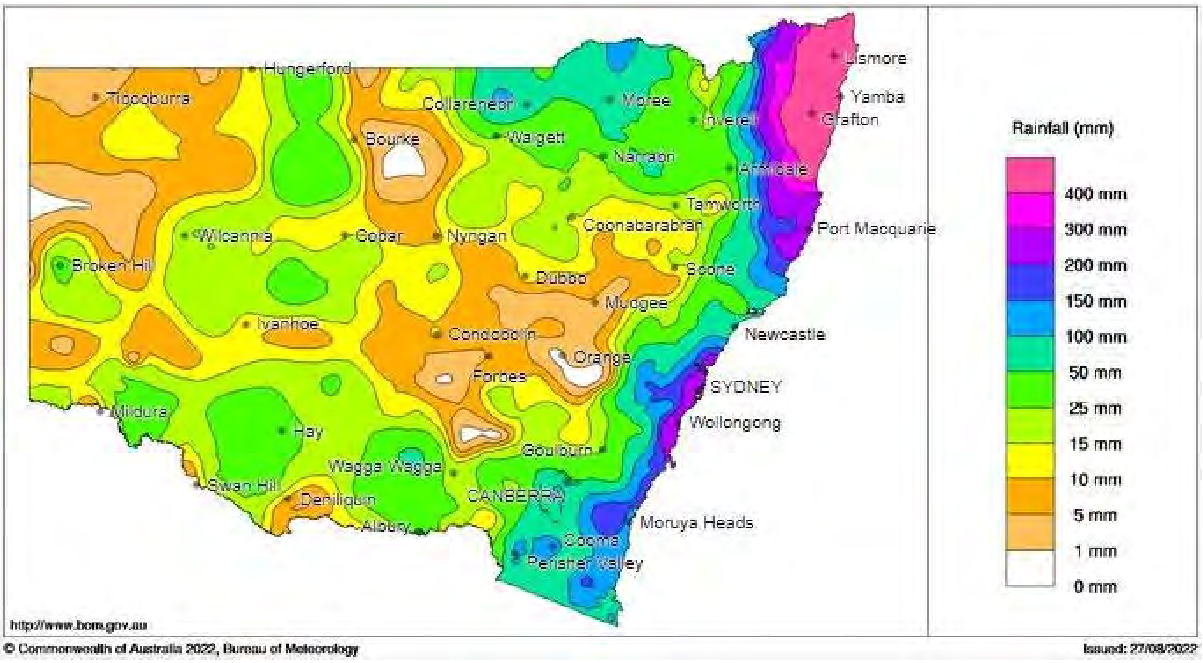

Figure 4: Weekly rainfall totals for NSW (23/02/2022 – 01/03/2022), showing 200+ mm to 400+ mm in the subject catchments.

Figure 5: Lismore McDonald’s before and at or near the flood peak (Guardian newspaper).

3 THE SES FLOOD INTELLIGENCE GATHERING PROJECT

3.1 NSW SES Operations Order

At or within 24 hours post major flood peak levels of the Northern Rivers systems, including Wilson (Lismore at approximately 3 pm on Monday, 28 February 2022), Richmond, Tweed and Clarence rivers, NSW SES issued an Operations Order for field intelligence collection and post flood report of peak water levels to the Public Works Advisory (PWA), now NSW Public Works in the Department of Regional NSW (Figure 6). PWA Project Manager/Engineer Fred Spain received the order for dissemination, requesting assistance in planning and project managing field reconnaissance, collecting information and intelligence for validation of flooding that occurred in the Richmond, Wilsons, Brunswick, Clarence and lower Tweed rivers and Marshalls Creek river systems.

The Operations Order’s mission outlined three key objectives:

1) Understand real-time flood consequences to inform the ongoing response, resupply and potential recovery.
2) Provide detailed hazard and consequence information to validate and update NSW SES flood plans.
3) Provide detailed report of river conditions, hydraulics and hydrology of this event in an after-event report.

The general outline for the execution noted:

- How data was to be collected.
- Priority area.
- Types of data to be collected.
- Property access requirements.
- Administration and logistics.
- Work Health and Safety (WHS) and key risks.
- SES command, control and communications contacts.

FOR OFFICIAL USE ONLY

SES
NSW STATE EMERGENCY SERVICE

Operations Order – Field Intelligence Collection and Post Flood Report
1230hrs 1/03/2022

ISSUE #: 1

NSW SES Event Number: 261/2122

Event type: Riverine Flooding

Event Location: Northern, NSW

TO:	Public Works Advisory
FROM:	SCC Intelligence Officer

SITUATION

NSW SES is responding to Major flooding across the northern rivers of NSW including Richmond, Wilsons, Clarence, Tweed, Nambucca and Bellingen Rivers and Coffs Creek. Alongside operational response, NSW SES require accurate and timely field intelligence to be captured to inform planning for response and transition to recovery.

A collection of river conditions, hydraulics and hydrology of this event in an after event report would assist in current and future event preparations.

Figure 6: Extract from SES Operations Order to PWA.

3.2 PWA Internal Project Planning (02/03/2022)

The PWA Principal Surveyor held internal meetings with the PWA Project Manager and other key PWA staff to plan and strategize the execution of the SES Operations Order. An agile plan was required to allow for the timely capture of key ‘on-the-ground’ intel prior to further follow-up weather events ‘corrupting’ available evidence.

The PWA Surveying & Spatial team worked closely together to:

- Identify strategically located and available survey field staff to collect field data.
- Create and provide instruction on how to ‘capture’ intel in SES’s preferred GIS app.
- Provide datum, survey methodology and quality control parameters.
- Determine data delivery attributes and format.
- Determine point capture density.
- Identify and allocate the Areas of Interest (AOIs) – updated throughout the project.

Access due to flooding to, in and around the AOIs, as well as survey operatives identified to possibly engage in this project, may be directly or indirectly flood-affected themselves. Consequently, the operational decisions of this time-sensitive project were required to be strategic and flexible but maintaining continuity. Therefore, frequent project updates would be required between survey staff on the ground, their managers, the PWA Surveying & Spatial team and SES.

3.2.1 Stand-Up of Floodplain Working Group

The NSW Department of Planning and Environment’s (DPE’s) Floodplain division engaged the services of WMA Water, a well-established consultancy group specialising in hydrological and hydraulic studies of waterways and floodplains, and the development of long-term strategies and designs for management of flood and water resource risks.

DPE and WMA met regularly with local authority (council) floodplain engineers in the weeks following the event to coordinate a response to impacted areas, of which the flood intelligence capture requirement was emphasised as a priority. During this period, strategic locations were identified for intel gathering, which would best serve SES's needs and also provide knowledge for future floodplain management.

3.2.2 Engagement of DCS Spatial Services – Survey Operations Regional (03/03/2022)

The PWA Principal Surveyor reached out to DCS Spatial Services, a unit of the NSW Department of Customer Services (DCS), in particular its Survey Operations Regional (SOR) Manager/Senior Surveyor to ask for assistance from SOR staff located within the proximity of affected areas specified in the SES Operations Order. SOR staff from Coffs Harbour (2) and Lismore (2) were contacted by their manager after his initial contact and briefing from PWA to convey the SES request and to check for staff availability to commence work on the SES flood intelligence gathering project as soon as possible.

An MS Teams briefing was set up by PWA with SOR staff for Thursday afternoon, just 48 hours after the SES Operations Order was issued. Of the four SOR field surveyors, two were ready to respond as soon as possible. One was assisting their parents who were flooded in Lismore, and another had already been active for 8 days with Grafton City SES. As such, the latter two were unavailable until the following Monday.

3.2.3 Engagement of Private Sector Surveyors via Fee-For-Service (03/03/2022)

PWA also engaged several private sector surveying consultancies located in the Northern Rivers region to assist with the on-the-ground works. The key contacts for the consultancies were very willing to assist and offered resources to be available within 48 hours of initial contact. The consultancies engaged and respective key contacts were:
- RCS Group – Tony Riordan.
- Newton Denny Chapelle – Jeff Pickford.
- Fletcher and Associates – Andrew Fletcher.

3.3 Intel Capture

This paper aims to conveys the project experiences of, and between, SOR, PWA and SES. Its focus is therefore on agility and flexibility of the public authority surveyor, with the support of their senior managers, to execute surveys that prioritise the NSW community, and not commercial gain, in time of natural disasters or emergencies within NSW. This includes experiences and stories from those in the field, what they saw collecting data for this project, the people they interacted with, and an attempt to convey the delicate human nature of this project after such devastation and loss. This does not take away from the contribution of the private fee-for-service surveyors and survey firms, who shared similar experiences and without their involvement achieving a timely outcome for the SES Operations Order may not have been possible (Table 1).

It should be noted that PWA reached out to local authorities, who may have had 'staff surveyors' on board, to see if they were able to contribute to the intel capture project. Understandably, affected Local Government Areas (LGAs) were accessing and dealing with major impacts to their infrastructure, such as road, bridges and landslips, and were driven to overcome those impacts as soon as possible for their rate payers and residents.

During and after the event, PWA received survey data from the following LGA survey contacts:

- Ballina Shire Council – David Kelly (surveyor).
- Tweed Shire Council – Mitchell Liddell (surveyor).

Table 1 (extracted from the Survey Data Report – North Coast Flooding 03-2022 Emergency Flood Survey Works) has been expanded to include villages and localities on the Orara River, which feeds the Clarence River, for the purpose of this paper. While this was not part of the original SES Operations Order, communication from Folley (also Grafton City SES – Deputy Unit Commander) to PWA outlined that flood intelligence for impacted villages and localities on the Orara River would be of considerable benefit to the organisation. PWA confirmed this need with the SES Clarence Valley Deputy Local Commander, who clarified and expanded the locations where intelligence would be of most benefit.

Table 1: Towns, villages and localities captured (SOR in blue and purple, private surveyors in orange).

SES Description	Town	LGA
Tweed	Uki	Tweed
	Murwillumbah	Tweed
	Condong	Tweed
	Tumbulgum	Tweed
	Chinderah	Tweed
	Tweed Heads	Tweed
Marshalls Creek	Billinudgel	Byron Shire
	Ocean Shores and South Golden Beach	Byron Shire
Smaller Tweed Coast Catchments	Pottsville	Tweed
	Burringbar	Tweed
	Clothiers Creek	Tweed
Brunswick River	Mullumbimby (including Main Arm and Durrumbul)	Byron Shire
	Brunswick Heads	Byron Shire
Richmond/ Wilsons River	Goolmangar	Lismore
	Lismore	Lismore
	Kyogle	Kyogle
	Casino	Richmond Valley Council
	Greenridge	Richmond Valley Council
	Codrington	Richmond Valley Council
	Coraki	Richmond Valley Council
	Woodburn	Richmond Valley Council
Clarence River	Grafton	Clarence Valley
	Southgate	Clarence Valley
	Ulmarra	Clarence Valley
	Brushgrove	Clarence Valley
	Lawrence	Clarence Valley
	Maclean	Clarence Valley
	Crystal Waters	Clarence Valley
	Yamba	Clarence Valley
	Iluka	Clarence Valley
	Harwood	Clarence Valley
	Chatsworth Island	Clarence Valley
	Ashby	Clarence Valley
Orara River	Kangaroo Creek (Upper & Lower)	Clarence Valley
	Coutts Crossing & surrounding localiities	Clarence Valley

3.3.1 Intel Capture Platform

The SES Operations Order directed the use of, and supplied instruction of, the ArcGIS Collector app (Esri, 2023) for all intel capture. SES provided a project-specific login and password for access to their intelligence gathering maps that allow real-time ingestion into their statewide mapping and intelligence gathering systems. Part of the Esri Geospatial Cloud, ArcGIS Collector (now migrating to ArcGIS Field Maps), is a mobile data collection app that makes it easy to capture accurate data and return it to the office by using web maps on mobile devices to capture and edit data. ArcGIS Collector works even when disconnected from the internet and integrates seamlessly into ArcGIS.

The Intelligence Gathering (All Events) – Collector map was utilised for this project, one of several in a suite of maps utilised for various intelligence gathering activities by SES or by organisations gathering information on behalf of SES (Figure 7). For example, the Australian Army utilised the Damage Assessment map within the ArcGIS Collector app for building assessments of flood-affected, damaged or non-inhabitable housing post flood in Lismore.

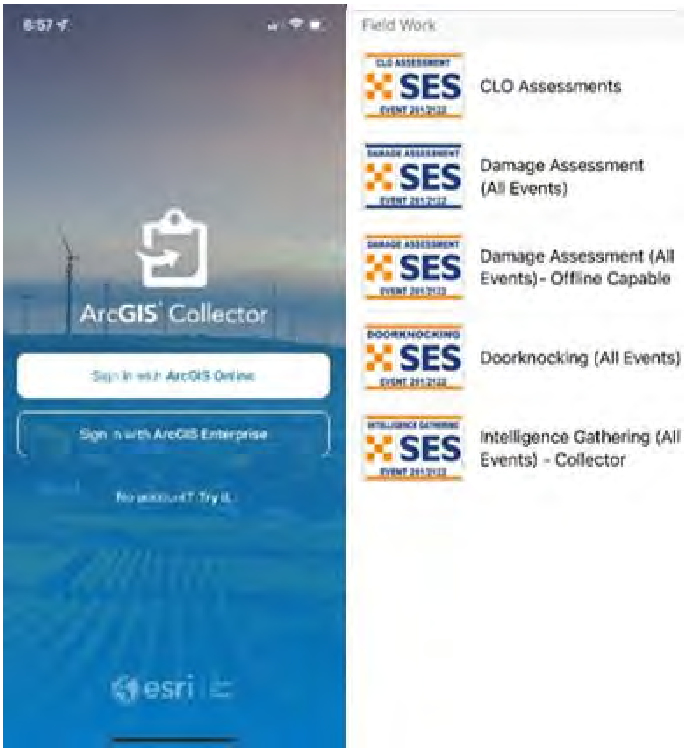

Figure 7: ArcGIS Collector app and SES intelligence/assessment maps.

Being a geospatial tool, capture locations were accurately 'pinned' on the map, evidence photos taken and stored, as well as comments noted about evidence surveyed and accurate Australian Height Datum (AHD – e.g. see Janssen and McElroy, 2021) values surveyed at the location of the evidence found (Figure 8). Positioning data was collected using the Global Navigation Satellite System (GNSS) Continuously Operating Reference Station (CORS) Real-Time Kinematic (RTK) technique. Positions were obtained through CORSnet-NSW, Australia's largest state-owned and operated GNSS CORS network providing fundamental positioning infrastructure for a wide range of applications (e.g. Janssen et al., 2016).

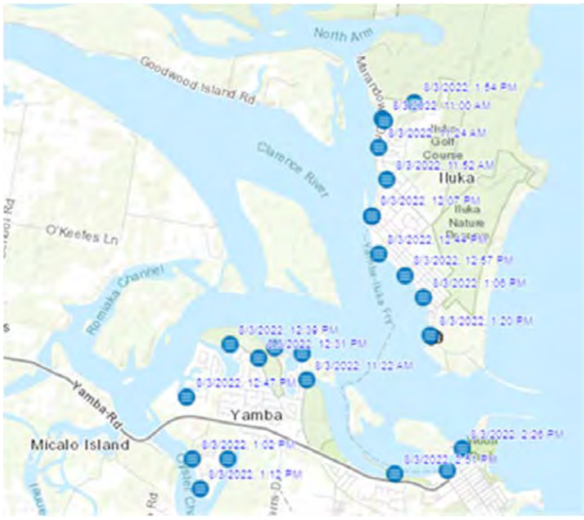

Figure 8: Sample of captured points within ArcGIS Collector.

3.3.2 Intel Capture: Datum, Methodology, Data Delivery Codes and Format

Most importantly, all captured evidence required accurate AHD heights for SES to capture the Peak Water Level (PWL) in this event and collate intelligence to assist the SES Planning and Intelligence Officers (e.g. flood analysts) in the preparation for any future events (Figure 9).

Coordinate System

MGA 2020

Height Datum

AHD (AUSGeoid2020)

Collection Method

GNSS - CORSnet RTK (single base or Network)

GNSS – Local single base using local established and approved SCIMS mark(s)

Note: Check shots to be made to accessible established and approved SCIMS mark(s) where possible

Field data collection

- Main objective is to determine peak levels of the flood.
- Any comments should be made using Code#Comment. The comment should specify how the peak water level was determined. Example;
  PWL#debris line

Code list

Code	Description
PWL	Peak Water Level
CWL	Current Water Level

Export format

- P,E,N,H,C,D,T
- Point Number, Easting, Northing, Height, Code, Date, Time.
- Example: 1000,333000.000,6500000.000,15.000,PWL#debris line,03/03/2022,1130

Figure 9: Extract from PWA survey briefing document.

PWA and SES determined a 500 m density sample rate for evidence to be captured. This capture density was applied as a rule of thumb for most of the areas within the AOIs. However, as time progressed, external inputs come forth to focus or direct the capture parameters.

As mentioned earlier, the SES flood intelligence gathering project received input from the DPE Floodplain group, which included affected council area's flood engineers and consultants who specialise in water engineering and flood modelling. Their involvement was likely to assist in identifying 'pinch-points' for this event and contribute to local water authorities future planning and mitigation for these types of events into the future.

The Byron Shire LGA capture was dictated by specified localities around watercourses, watercourse infrastructure (e.g. culvert or bridge), residential localities where waterflows (both riverine and stormwater) could be affected, and where evidence would contribute to later analysis (Figure 10).

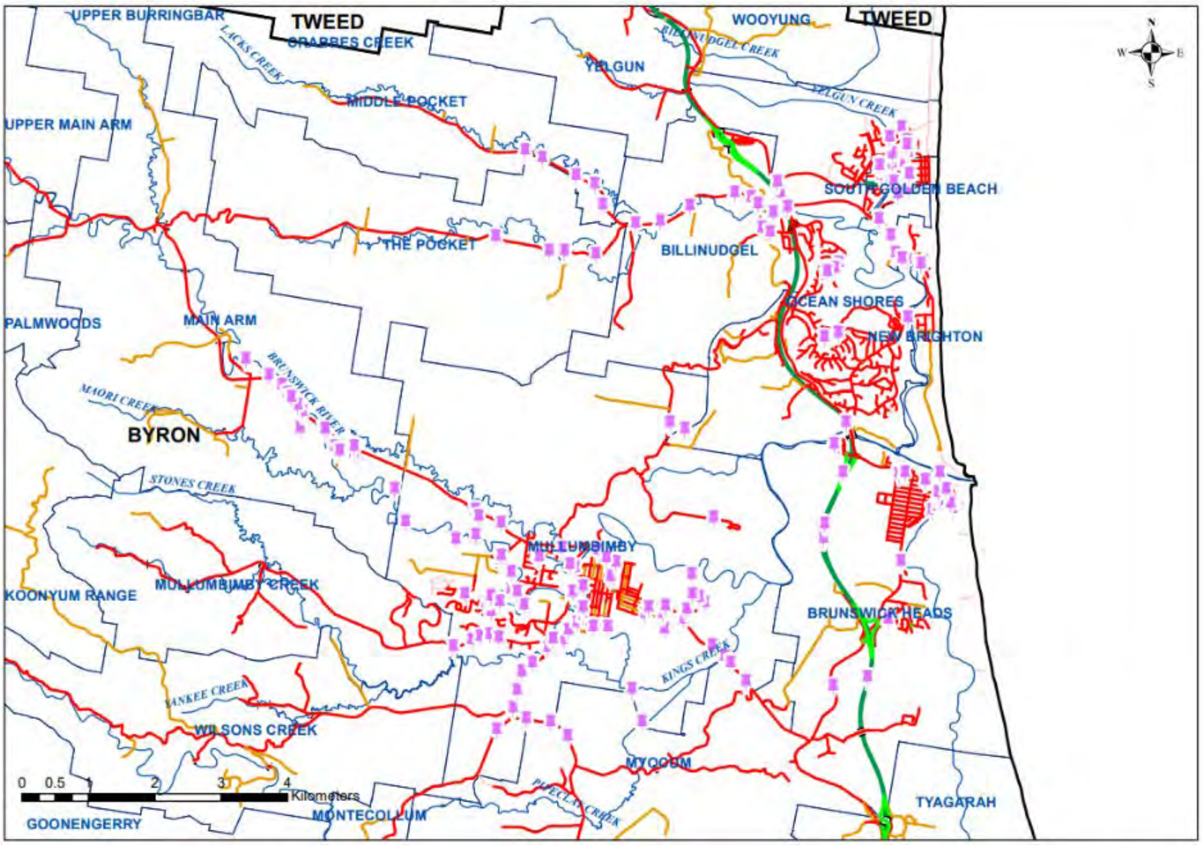

Figure 10: Capture locations provided in KMZ format for Byron Bay (first event).

3.4 Intel Capture: Byron Bay – Second Extreme Weather Event

Following 4 weeks of flood intelligence gathering from the first severe event, a second isolated weather event hit Byron Bay and Suffolk Park to the south on Tuesday, 29 March 2022. Heavy rain lashed the popular North Coast destination overnight and through the early morning of Wednesday, 30 March 2022 (BOM, 2022b), causing flash flooding and inundation throughout the Central Business District (CBD) and low-lying residential areas (Figure 11).

Figure 11: Flooding in Byron Bay, corner Jonson St & Byron St (30/03/2022) (Guardian newspaper).

Rainfall totalling almost 300 mm in 2 days (131 mm & 164 mm) fell in two of Byron Bay's flood management areas, Belongil Creek and Tallow Creek (Figures 12 & 13). Residents said flooding in the Tallow Creek flood area would have been devastating had Tallow Creek not been opened to the sea the previous month, which at that stage was at capacity with water levels about that captured in this project.

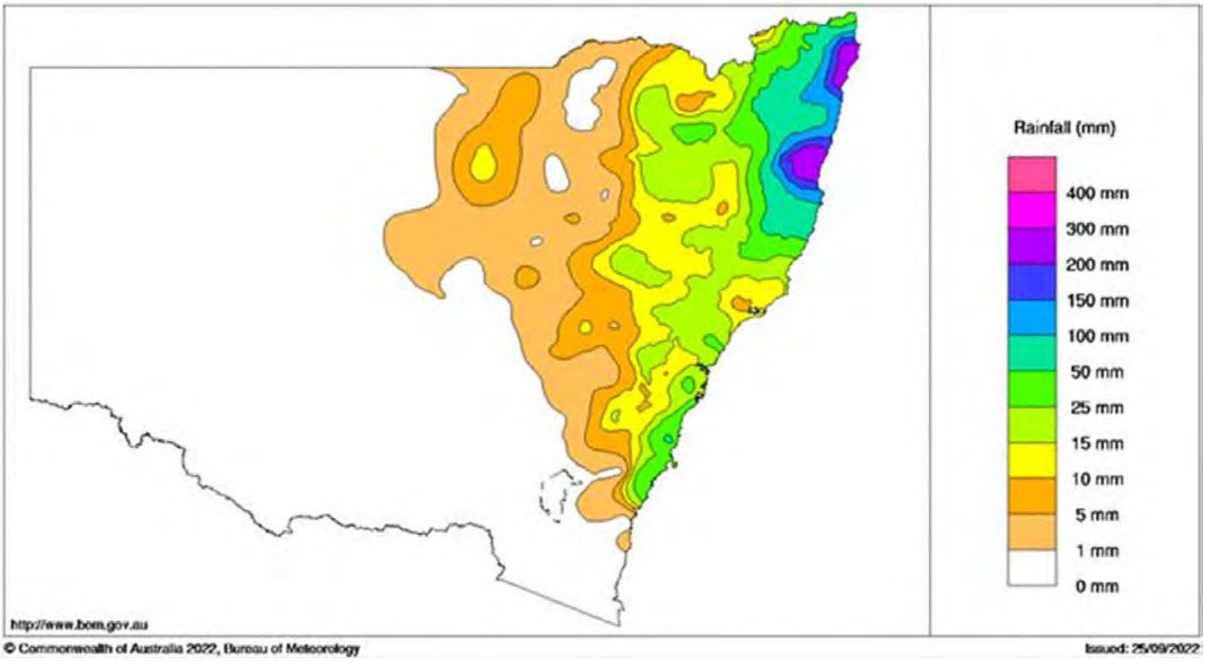

Figure 12: North Coast rainfall in the 24 hours to 9 am (30/03/2022).

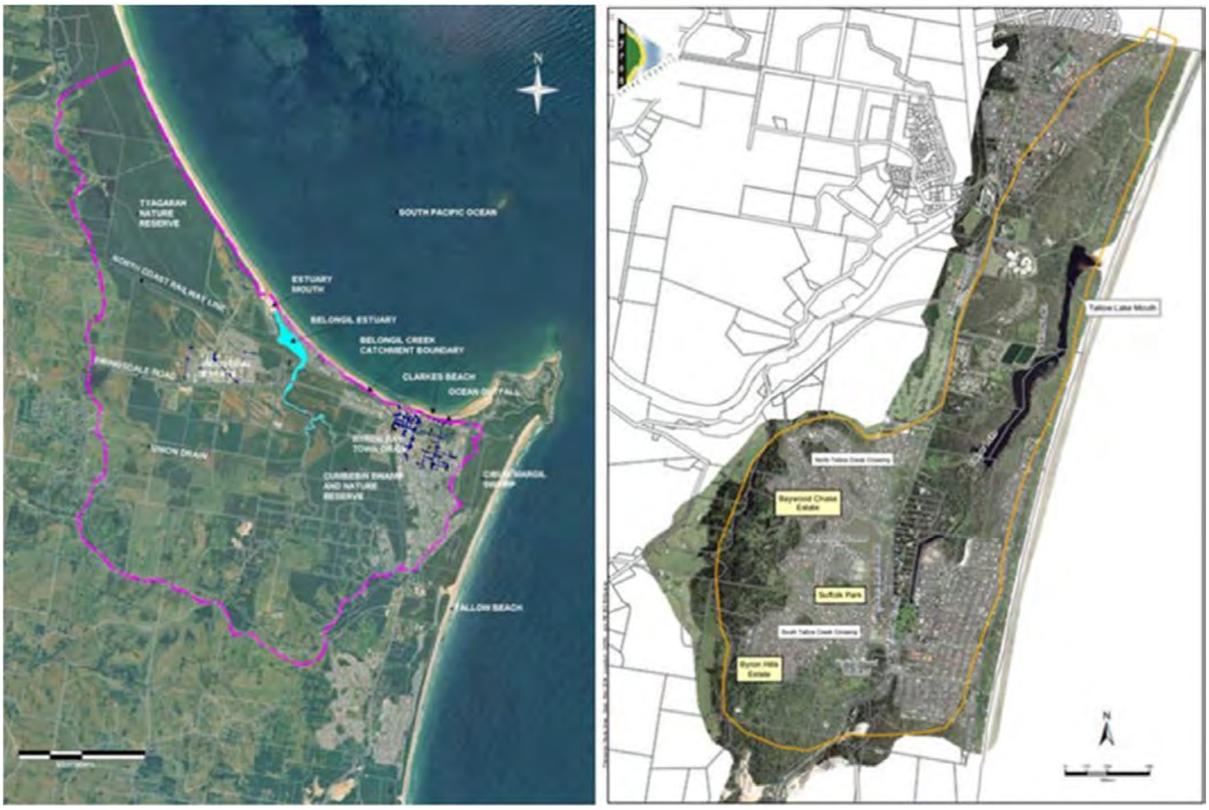

Figure 13: Byron Bay's flood areas – Belongil Creek (3,000 ha) and Tallow Creek (450 ha) (courtesy Byron Shire Council).

3.5 Intel Capture: PWL Evidence

Two types of flooding were encountered by SOR surveyors on this project: riverine (catchment) and stormwater (localised). Both had an overwhelming theme of PWL evidence, while the location of capture also perpetuated the trend of PWL evidence.

All PWL evidence surveyed needed to be definitive and 'trusted' (Table 2). Physical evidence was one source of evidence captured. SOR surveyors worked as one main team, therefore sometimes capturing points was quick and simple. However, often it was a time-consuming process, making contact, talking to residents, accessing their properties, identifying and confirming reliable evidence, or having access and offset locations that were difficult to take a 'quality' RTK shot at. Many PWL points had been marked up by residents, volunteers and workers, physically marking a surface (e.g. building, structure or road) with paint or Texta. Examples of various physical evidence are shown in Figures 14-23.

Table 2: Types of evidence captured.

Type of Evidence	Source or Located	Likely Source
Silt	Vegetation, buildings, structures	Riverine
Large debris	Roads, banks, paddocks, bridges, wire fence	Riverine
Scouring	Fences and concrete structures	Both
Fine debris	Fences, windows, screens	Stormwater
Markings	Buildings and structures (residents)	Riverine
Photos	Provided by residents or business owners	Both

Figure 14: Silt line on vegetation and structures.

Figure 15: Large debris remains near rivers.

Figure 16: Debris on the road and in paddocks (edge of large area flooding).

Figure 17: Scouring caused by debris moving past a structure.

Figure 18: Small debris requiring horizontal offsets.

Figure 19: Debris on underside of bridge structures, requiring vertical offsets.

Figure 20: Light debris remains on motorised vehicles.

Figure 21: Marking provided by residents, volunteers and/or workers.

Figure 22: Photographic PWL evidence captured by resident (time/date captured).

Figure 23: Photographic PWL evidence captured by resident (time/date captured).

3.5.1 Intel Capture: PWL & CWL Captured

Overall, there were 651 PWLs and 27 CWL values collected across the project, which included the initial event and secondary event later in March around Byron Bay. However, in July 2022, as a result of a proactive community engagement campaign by local authorities post flood events, residents who had captured or recorded PWLs, either by physically marking or via photo or video evidence, could register their interest in sharing their intel with their local authority for capture in the flood intelligence gathering project. A private fee-for-service survey contractor was engaged to capture that evidence, with those responses contributing a further 108 PWLs.

Originally, flood intelligence was captured with the ArcGIS Collector app (photo evidence, type and source of evidence, AHD level surveyed), with .CSV survey data (containing all relevant metadata, including time, date, position and AHD level) sent from surveyors to PWA at the finalisation of their capture commitment. However, access to SES intelligence gathering maps were time sensitive, limiting access to a wider user audience. Therefore, PWA made the decision to import and share all .CSV data between SES, councils, PWA and DPE through MS Teams and Esri software (Figures 24-28).

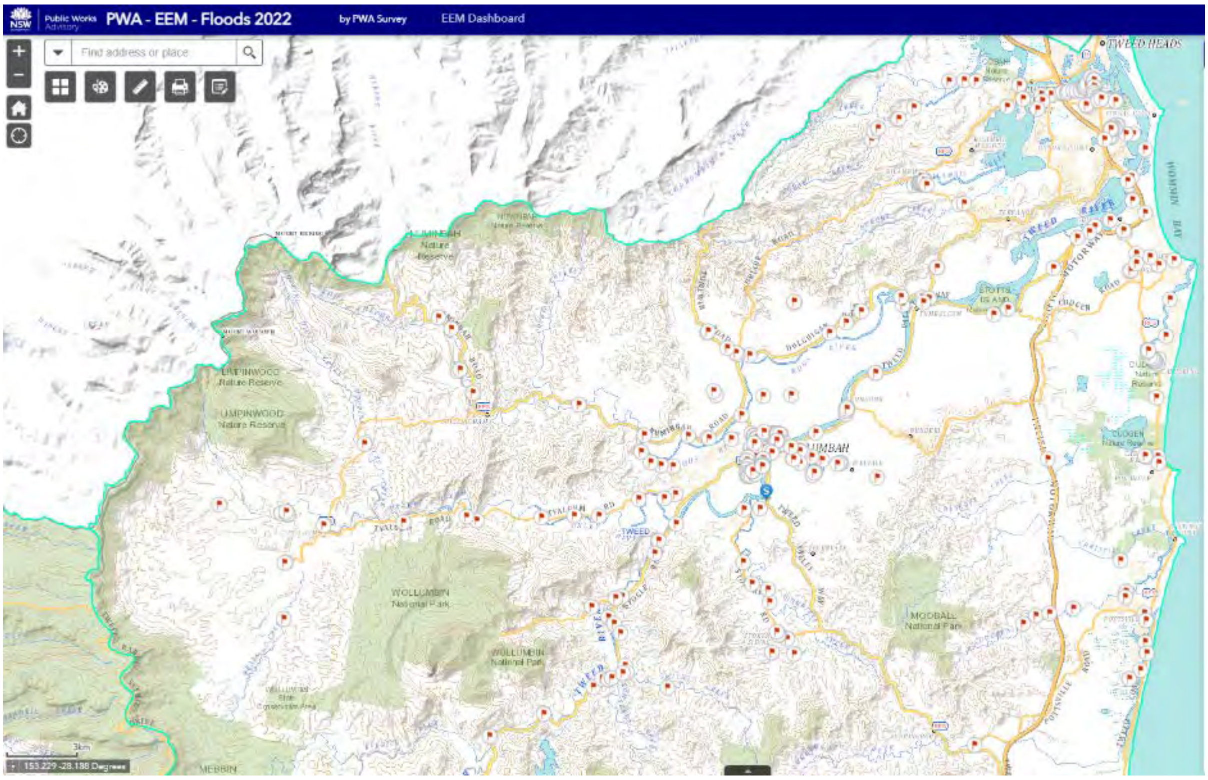

Figure 24: Tweed River and smaller Tweed Coast catchments.

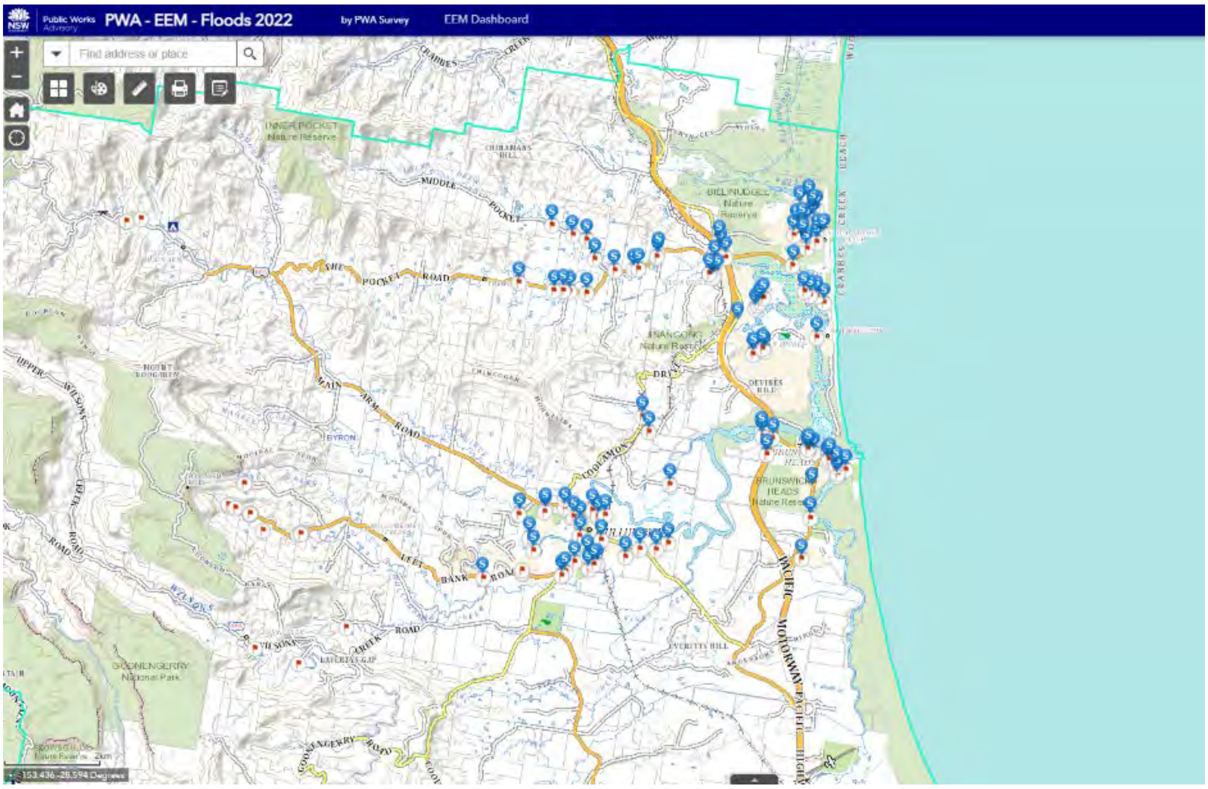

Figure 25: Brunswick River / Marshall Creek catchments, Byron Shire.

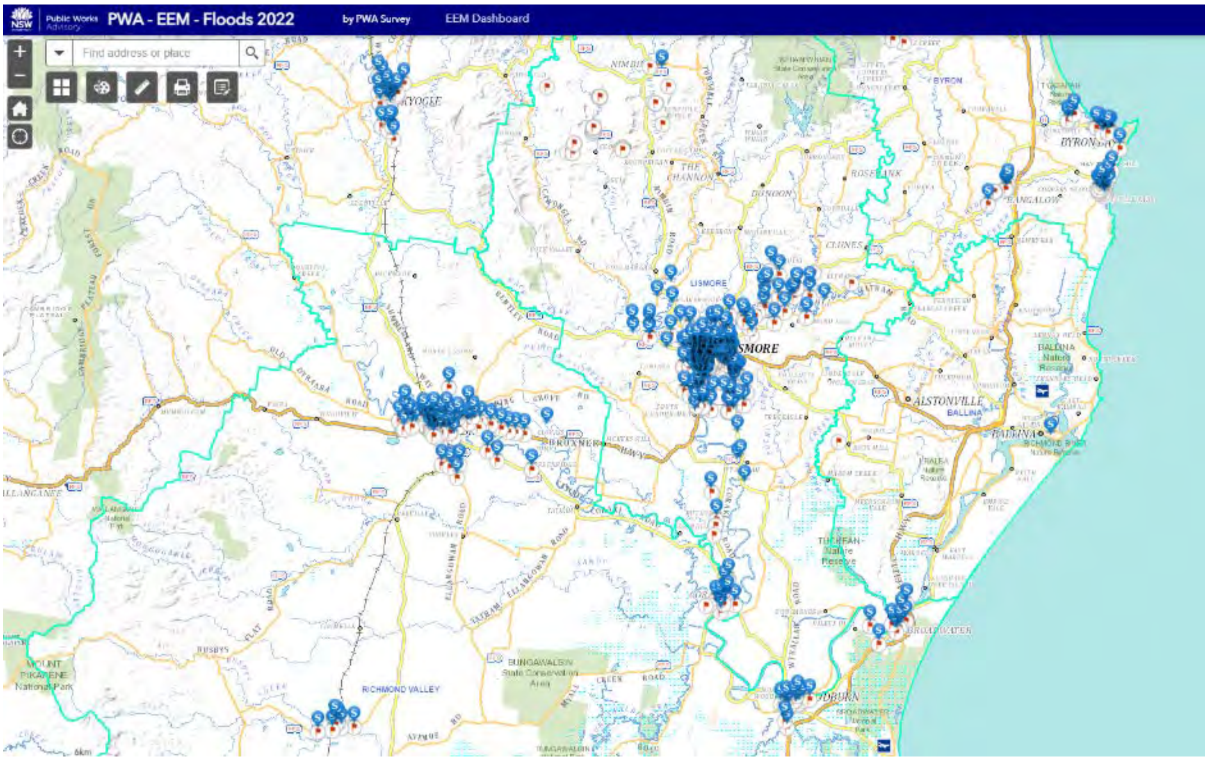

Figure 26: Richmond and Wilson River catchments (also shows Rappville & Byron – not in catchment).

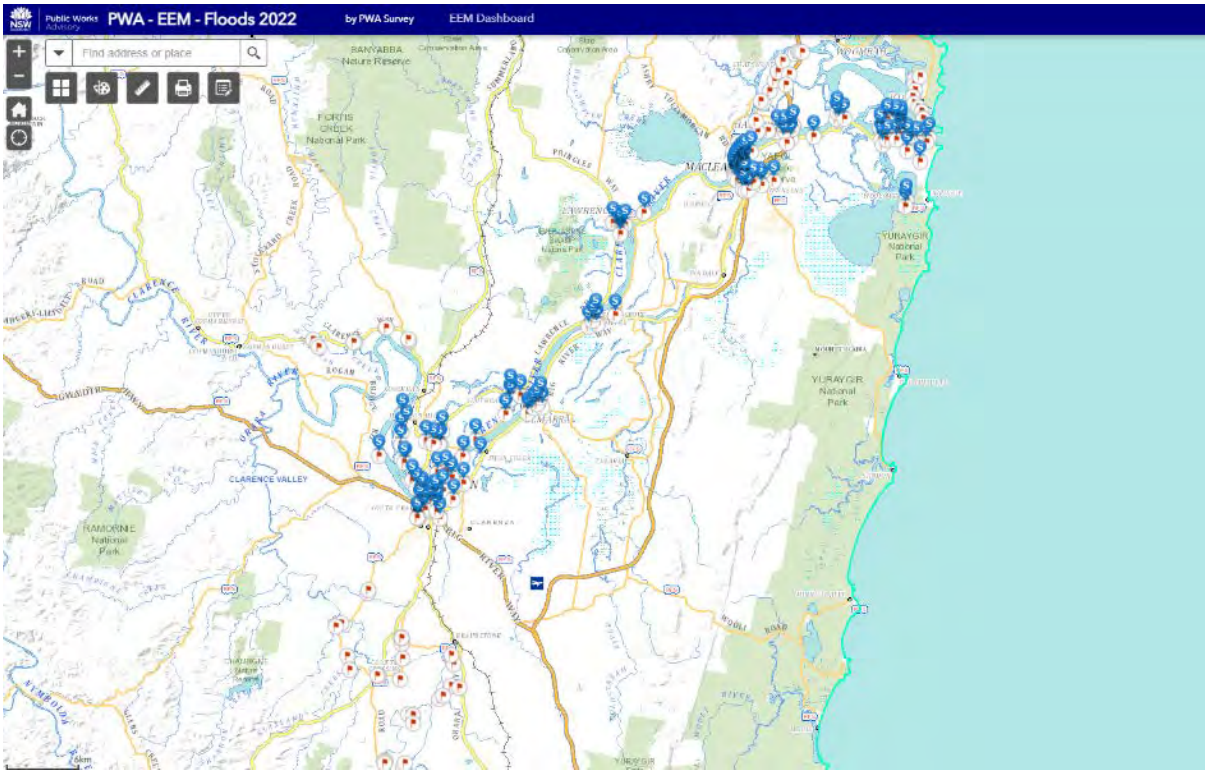

Figure 27: Clarence River and Orara River (feeds Clarence River) catchments.

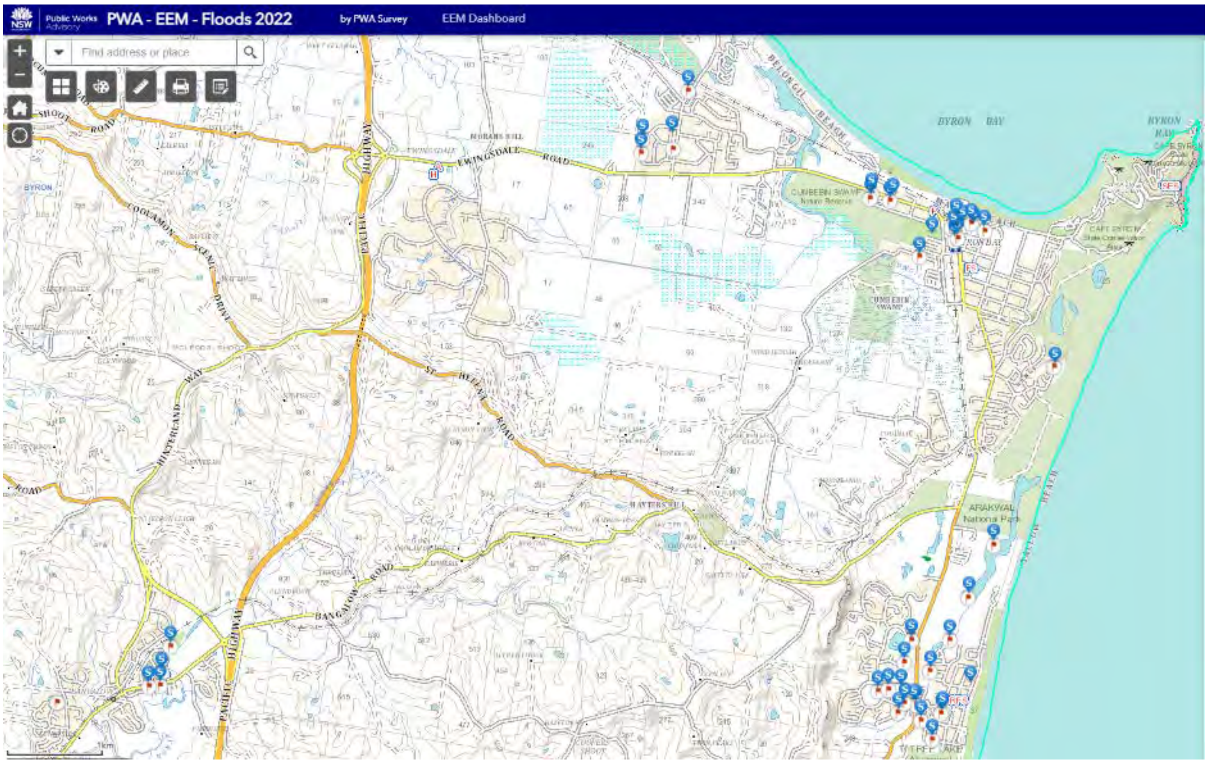

Figure 28: Byron Bay, Suffolk Park / Tallow Beach and Bangalow – second severe weather event.

4 THE PUBLIC SURVEYORS' EXPERIENCE

4.1 What Would We See and What Would Be the Public Reception?

The SES Operations Order included under 'Safety', its 'Key Risks'. According to the Order, the first two key risks which exist in any flood event are:

- Exposure to traumatic incidents or scenes.
- Distraught or outraged residents: Residents may take out their frustrations about the situation on teams. Use all courtesies and empathy when dealing with this type of resident and do not engage in arguments. Refer any people that may require flood rescue or other assistance to NSW SES 132500, for life threatening emergencies call 000. Remove yourself from the property immediately, if you feel threatened in any way and report the issue.

Digital media outlets and social media had been quite critical of the NSW and federal government's response, as well as that of the emergency services and the Australian Defence Force (ADF), post flooding in the Northern Rivers and surrounding areas. Was this going to be the same for SOR surveyors, with their vehicles easily identifiable and the need to talk with residents and seek access to private residences to capture intel?

4.2 The Scenes Were Humbling

Just like seeing and hearing your relatives' or friends' photos and stories after their recent travels, it is hard to capture the vastness, beauty or feel for a location if you have not seen it for yourself. To travel down streets one after the other, locality after locality, to see houses that have been gutted and their contents stacked, waiting to be picked up in a mass clean up (Figures 29 & 30). Cars with their doors, boots and bonnets opened with the hope of drying out before more rain comes.

Some areas were a hive of activity, some had the feel of a ghost town, as people were either busily trying to restore normality after the past few weeks or had sort living arrangements in other locations until damage assessments and insurance work could see them return. Displaced residents form all over the Northern Rivers could be found 'pitching a tent' somewhere where services were available, living in their cars with all their 'worldly possessions', or if they were lucky enough, using NSW government vouchers to gain temporary accommodation in all directions outside the disaster zone. One of the authors had to seek accommodation in South Tweed (over 50 km from their current AOI), where displaced residents were the main occupants of the motel and several others in the local area.

The coming months would see some suburbs look like trailer parks as residents bought and lived in caravans outside their homes as an already 'strained' building industry from the COVID-19 pandemic and supply chain issues added to delays in the recovery. At the end of 2022, the Northern Rivers was still over-coming the flood earlier in the year, with residents and businesses being displaced, local infrastructure in disrepair, accommodation (both residential or holiday) under reconstruction or tired owners broken and selling up. Local services have been reduced, with unaffected areas carrying the burden.

Figure 29: South Golden Beach, Byron Shire LGA (17/03/2022).

Figure 30: Lismore drone capture of clean up (NCA NewsWire / Danielle Smith).

4.3 The Public's Reception to SOR Surveyors Collecting Intel

It was not long for SOR surveyors to develop their 'greeting' speech when interacting with the residents of affected areas. Generally, dialogue would usually start with "Hi, how have you been getting on the last week or two?", which may include "Do you live here?" and then… just listen! This would give the resident the opportunity to tell their story of how they, their neighbour(s), their family or friends had been affected, and the type of challenges they had faced during and post flooding.

Most residents were more than willing to 'open up' and be very transparent. This would usually lead to the question of "What are you doing?", to which our response was generally along the lines of "We work for NSW Spatial Services, the old Central Mapping Authority" (this is generally our normal greeting in our day-to-day work, as no one usually knows of DCS Spatial Services). "We have been engaged by Public Works to capture Peak Water Levels from the recent flood event for the NSW SES." Some would accept that answer, some would ask, "What's that for?", which was generally replied to with "The SES is gathering flood intelligence to understand what happened and share the information with other authorities to better plan to deal with any future events."

We also experienced some resistance or negativity. However, this was counteracted by either our empathetic approach or the realisation that the 'authorities' were being 'pro-active' so soon after the event and wanted the public's assistance to do so, or a combination of both. The public opened up such that we got the sense we were being part of the healing process. The residents just having someone to listen to their stories and knowing someone was doing something that may assist them, even if that was not something tangible at the time, was very powerful. The surveyors felt privileged and grateful to be part of the public's road to recovery, but also be the face of government agencies assisting the public after such devastation and emotional turmoil. At times, collecting points or intel was very time consuming, with plenty of offers to come inside to see the damage and/or have a cup of tea, but we believe the time was well spent for all involved, particularly knowing word was getting around of why we were there!

4.4 Stories from the Field

Matisse Thiering was talking to a business owner in Maclean. He said his son was out and about at around 10 pm (28/02/2022) and noticed that the levee was starting to fracture at a location in the CBD. This was circulated on social media, which soon had members of the public in full swing, sand-bagging the weakened location. This action may have prevented a major impact as the levee wall continued to be sand bagged into the following day for several hundred metres, and most flooding was from localised rain inside the levee.

Graeme Davies visited a family at Gundirimba, close to the river, who had an earth mound built up in the paddock where they put their vehicles, machinery and four horses, high and dry, and had saved them in the 2017 flood. This time they put all the vehicles, tractors, horse float, and the horses (in a temporary yard) on the same hill. However, this time the flood level exceeded any previous ones by almost 2 metres, meaning that the water went over the top of everything and two of the horses perished where they stood while two others were found somewhere downstream a few days later. In the distraught young couples' words: "We made a death trap".

Graeme Davies' Ducati dealer and mechanic, Arthur Davis has a bunch of flooded motorcycles at his shop from all over the area. He was told that one bloke from Coraki lost his bike and put in an insurance claim. The insurance company replied that they may need a receipt or paperwork, etc. He said: "Mate, I have been past my house in a boat a couple of times this week, I can barely see the roof. Not sure where that paperwork will be!"

Stewart Folley talked to a landlord who was attending his cluster of villas in Brunswick Heads to allow insurance accessors carry out their duties. He was told: “We had my father at our place not far from here, he was going through home palliative care. He died on the night of the flooding, and we had to wrap him in plastic and store him in the back of my ute until the flood waters receded so an ambulance could pick up the body.” This was accompanied by a photo of his father in the back of his ute, mummified in cling-wrap, where he had to remain for several days.

Stewart Folley spoke to a middle-aged disabled guy who was in a wheelchair and was awoken to flood water. He had nowhere to go, and the water was up to his chest and neck. He was just lucky that the water level did not go any higher.

5 CONCLUDING REMARKS

Following the devastating flooding in north-eastern NSW in late February, March and early April of 2022, this paper has discussed the surveying technique, project outcomes, statistics and lessons learnt from the SES flood intelligence gathering project. It has also told a story of grieving and healing, resilience, power of community after a natural disaster, and the delicate situation the surveyors found themselves in when capturing the much-needed data during this challenging time.

The importance and value of the public authority surveyor has been demonstrated many times throughout this paper. A rapid and practical solution was required to respond to the SES Operations Order, which involved collaborating effectively with many stakeholders including those that could hit the ground running. Challenges always arrive in emergency situations and the ability for the surveyor to adapt to unpredicted field events and continue to deliver is often overlooked. On the grand scale of the event, the flood intelligence capture operations were quite small, but they were critical and very fulfilling for all parties involved.

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- Fred Spain, Project Manager/Engineer, NSW Public Works.
- Scott Moffett, Flood & Drainage Engineer, Byron Shire Council.
- Tony Riordan, Director, RCS Group.
- Jeff Pickford, Surveyor, Newton Denny Chapelle.
- Andrew Fletcher, Director, Fletcher and Associates.

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Pirates and Their Treasures of the Cadastre

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ABSTRACT

The Surveying and Spatial Information Regulation, Surveyor-General's Directions, Registrar General's Guidelines, historical precedence and plan registration procedures exist to ensure the integrity of the cadastre. But despite these documents and ensuring protocols, mistakes do happen. Searching through registered plans will reveal a significant number that, when examined closely, should not exist because they have gross errors that have escaped scrutiny. Those errors can even be a result of the survey not complying with the Regulation. The result is a cadastre that has many hidden treasures where an unentitled benefit has been gained. But where and how did these treasures come about and who are the pirates that plundered the protocols to ensure the treasures became hidden within the cadastre. This paper explores some of the survey plans that should not be, showing the treasures and how they came about. And the pirates…?

KEYWORDS: *Cadastre, integrity, errors, survey plans, pirates, treasures.*

1 INTRODUCTION

The production of the cadastre, i.e. the physical property boundaries out in the real world, and the mapped record of that reality require many components to bring it into existence. Educators, surveyors, map producers, record keepers, verifiers, legislators, legal practitioners, rules, regulations and directions all have their input. Some more than others and probably including more that have not been listed here.

Mostly things run smoothly as there are components in place that exist supposedly to protect the integrity of the cadastre. But sometimes things do not go according to theory as rules or directions are either ignored for the sake of convenience or practices have evolved that cause a bending of the rules (Songberg, 2020). The results are errors that create unintended and often undisclosed consequences, sometimes creating treasures buried within the cadastre. Even the rules themselves are not what the writers intended and have consequences that were not envisaged (Songberg, 2021). When things do not run smoothly, pirates (not to be confused with Murphy) magically appear, casting their treacherous fingers into the works and creating ripples in the cadastral sea, which allow treasures to be buried that might never be discovered.

Step up onto the deck, hoist the sails and cast off as we set sail across the seemingly calm cadastral sea in search of pirates and hidden treasure. Where are the treasures, how were they plundered, where are they buried, who are the pirates and just how bumpy is the supposedly calm cadastre? This paper aims to answer these questions by presenting several examples.

2 EXAMPLE A (2017)

In Figure 1, an approval has been given to the tidal riparian boundary and so all seems to be correct and the survey plan is registered. However, if you dig a little below the surface and examine the previous plan (Figure 2), it is discovered that the boundary at the bottom of the image is 5.145 m shorter than on the new plan and there is a reclamation extending out from the tidal boundary to a sea wall. A good setting for hidden treasures…

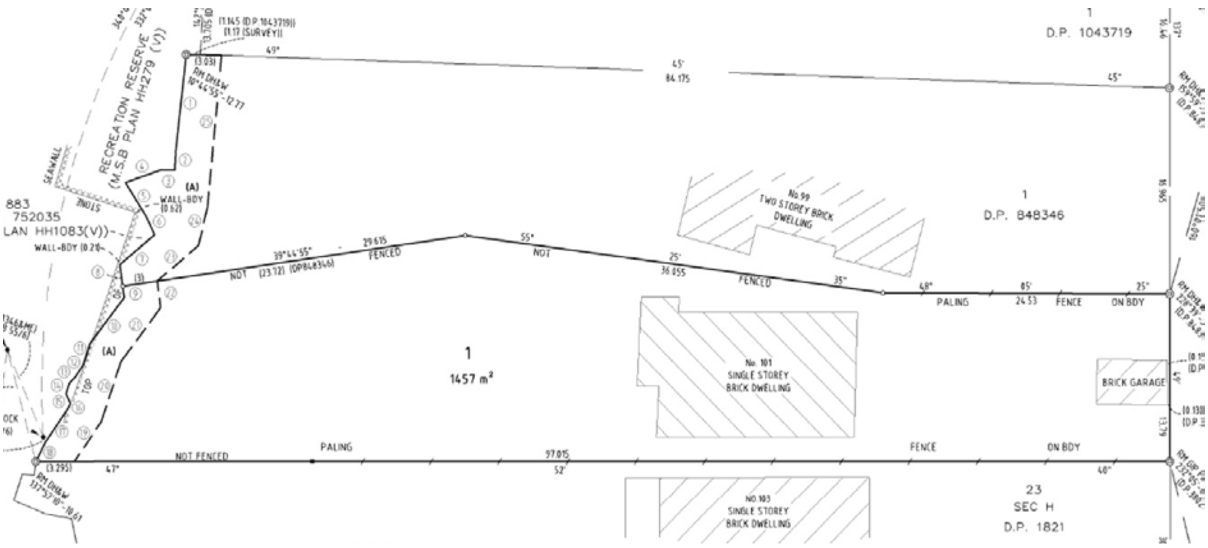

Figure 1: Plan A1.

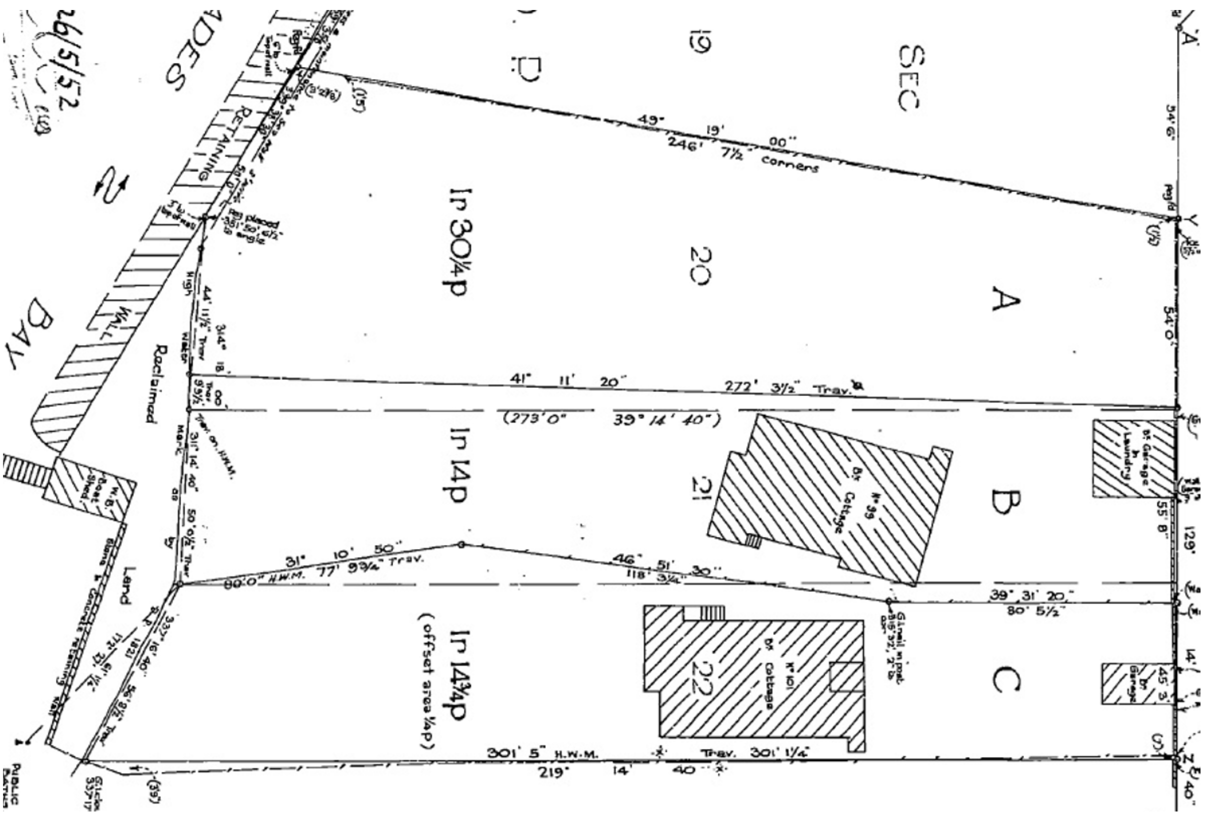

Figure 2: Plan A2, predating plan A1.

2.1 The Errors

The Surveying and Spatial Information Regulation 2017 (NSW Legislation, 2023), the current regulation at the time of writing, states at Clause 48(3): "If the change in the position of the mean high-water mark arose otherwise than from natural, gradual and imperceptible accretion or erosion, the position of the mean high-water mark, as defined by a survey plan, survey report or survey record filed or recorded by the Registrar-General or a public authority before the change, is to be adopted." A clause of the same wording existed in the regulation of the time of survey. This rule is an extension of the doctrine of accretion and erosion. Because the change, i.e. the reclamation, has not occurred gradually and imperceptibly, but rather deliberately, the riparian boundary does not change in subsequent plans and the reclamation remains part of the land below the old line of mean high water. Plan A1 (Figure 1) clearly shows the new boundary about the retaining wall around the line of the new boundary and not where it should be at the old line.

2.2 The Treasures

This example contains two treasures (Figure 3). The first is a gain of land shown hatched in Figure 3. This was all reclaimed land and according to the regulations should not have been included in the survey. The other treasure is the easement, which derives a benefit to two other lots. The easement allows two sets of landowners to pass along the foreshore across one lot to the foreshore facing a road.

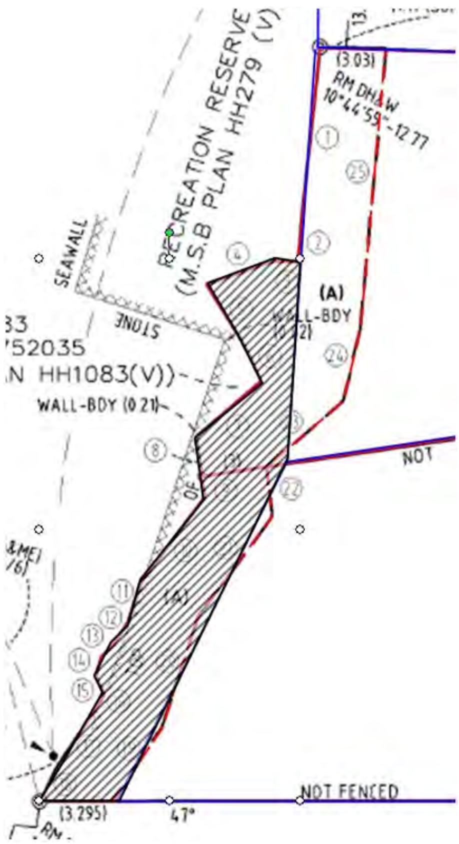

Figure 3: Plan A1 treasures – gain of hatched land and easement shown in brown.

2.3 The Pirates

In this instance, there is not one but several pirates. The first pirate that obviously comes to mind is the surveyor for ignoring the regulations and creating a plan clearly contrary to the rules. The landowners could be considered another crew of pirates as they had sought to have this plan undertaken. Was there some agenda that facilitated this action?

Another pirate is protocol. Usually, for tidal boundary approvals, consent is needed from the minister administering the Crown Lands Act. However, in this instance, because the tidal waters form part of Sydney Harbour, the harbour authority needs to be consulted, as detailed in Surveyor-General’s Direction No. 6: Water as a Boundary (DCS Spatial Services, 2016). The only problem is that the port authority has developed its own boundary of the harbour along lines that it considers to limit its interest. That line of interest, although labelled Mean High Water Mark (MHWM), is not always the same MHWM as determined by the land-based surveys. Sometimes there is a hiatus where the two determinations do not meet, and this is one such instance. Because protocol required approval by the harbour authority, which was duly gained, the authority governing the land within the hiatus, part of the reclamation, was ignored.

3 EXAMPLE B (2006)

This example consists of another plan with an approved MHWM, but this time combined with the landward boundary of a 100’ reserve definition. Figure 4 shows a plan that has successfully gone through the approval process for the riparian boundary and subsequently been registered. Inspection of the plan and information pertaining to local conditions provides a slightly different perspective as to whether or not this plan hides a treasure.

The Crown grant that this plan is within did not display on the face of the plan any notation as to the existence of a 100’ reservation from mean high water. The grant itself, however, has included in the exceptions and reservations “all land within 100 feet of High Water Mark.” The land is on the edge of the flood plain for the very tidal Clarence River, and Sandy Creek is tidal (or at least is shown to be tidal) to the east of the road on the east side of the plan. Information on local conditions relevant to Sandy Creek reveals that there is a weir west of the road that prevents the tide from reaching its natural extent up the creek. Now the situation does not seem straight forward and perhaps there should have been a bit more to the plan.

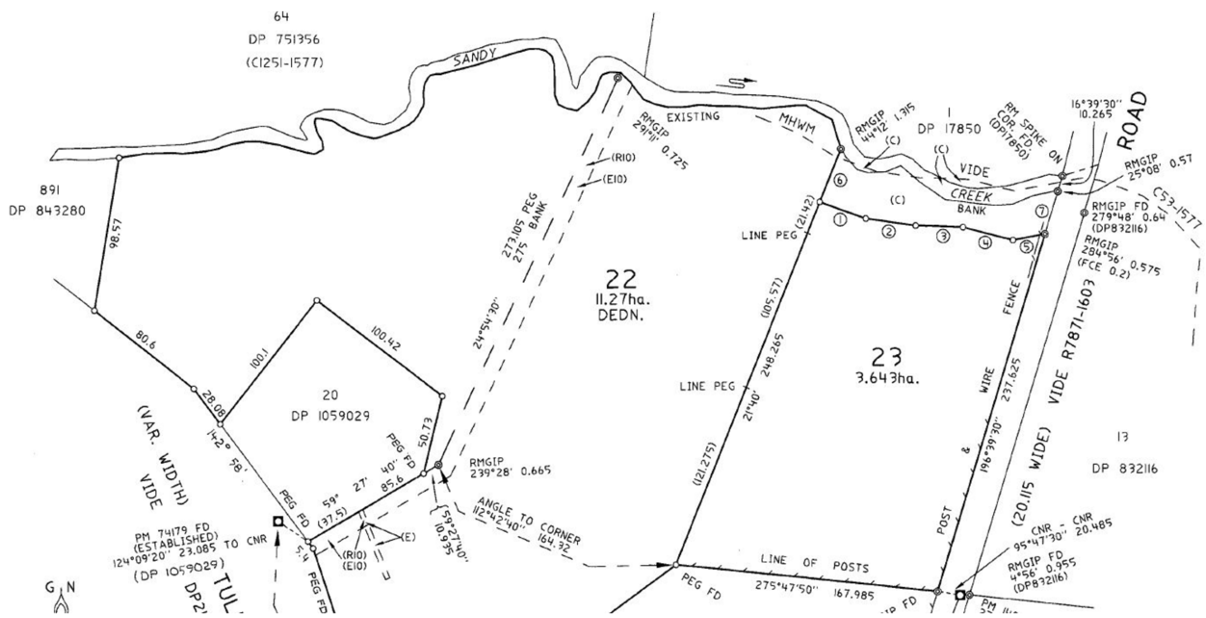

Figure 4: Plan B.

3.1 The Errors

The survey practice regulations, for quite a few incarnations, have required the surveyor to show any structure within 1 metre of a property boundary and provide offsets from that boundary. Riparian boundaries are not an exception from this requirement, and a weir would actually cross the MHWM and extend into the land a short distance. So where is the weir? It is not shown.

If the barrier is at the eastern edge of lot 22, the limit to which the reserve has been shown along the creek, then how much further up the creek would the tide naturally reach? Despite the weir, the creek is deemed tidal to its natural limit, yet that limit is not shown. The plan shows a half-completed tidal symbol on that part of the creek fronting lot 22 and also labels the riparian boundary as existing bank as opposed to the MHWM dashed from the grant plan. There is a lot to suggest that lot 22 should also show a 100' reserve, even if it is not defined by the plan. Should the tidal limit, and thus the reserve, extend beyond the easements (E10 and R10), then there would be an impact on the terms and conditions of those easements. It seems that this plan is not as complete as it should be, and there could be hidden treasure.

3.2 The Treasures

The missing reserve information from the plan gives the impression that there is more land available to lot 22 than that indicated. This is not the only plan, starting with the grant plan, that does not show the 100' reservation. There is even a plan in the sequence of subdivisions east of the road that does not show the reserve despite having an approval for MHWM. Lot 22 is not the only lot to have gained a treasure (Figure 5).

The non-disclosure of the weir does not produce as physical treasure but rather gives the treasure of greater simplicity to the land than what actually is. In some ways, the situation might even be considered as a hidden burden rather than a treasure.

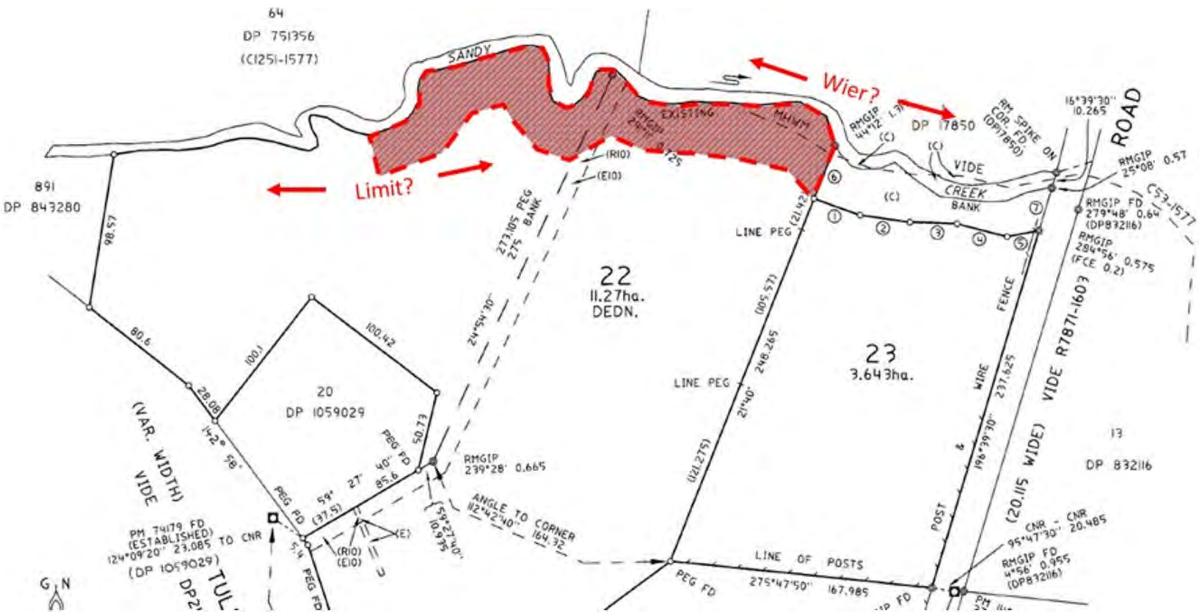

Figure 5: Plan B treasures.

3.3 The Pirates

The surveyor could be considered a pirate but not deliberately so. He was partially right but only showed part of the reserve. The fine print in a Crown grant creating the 100’ reserve from high water is often overlooked. Plans rarely show it, and it has caught many surveyors unaware. The approver for the tidal riparian boundary must also be considered a pirate, for not only this plan but the subdivision plans that precede it. The existence of the reserve has not been picked up until now but then only partially.

4 EXAMPLE C (1987)

Figure 6 shows a section of a plan for the property along the river. At first appearance, it seems like a job well done, but this is another land where pirates (intentionally or mistakenly) roam. Thoughts of hidden treasure start to appear when the previous plan and charting map are examined (Figure 7). These indicate that the bank was much further inland than that shown in Figure 6, and in between is a wide shingle bed. The latest plan does indicate the location of that bank as the high bank but only refers to the shingle as being grassed. The plan also identifies a lower shingle inside a bend of the river in the northwest.

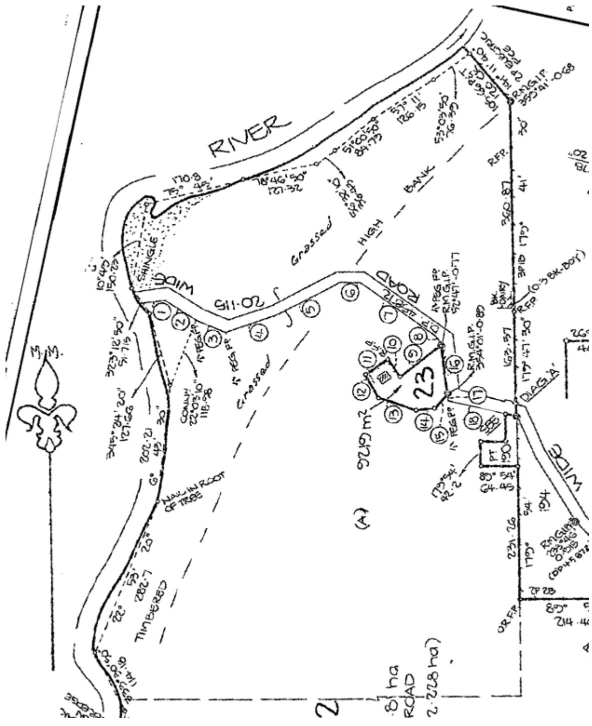

Figure 6: Plan C.

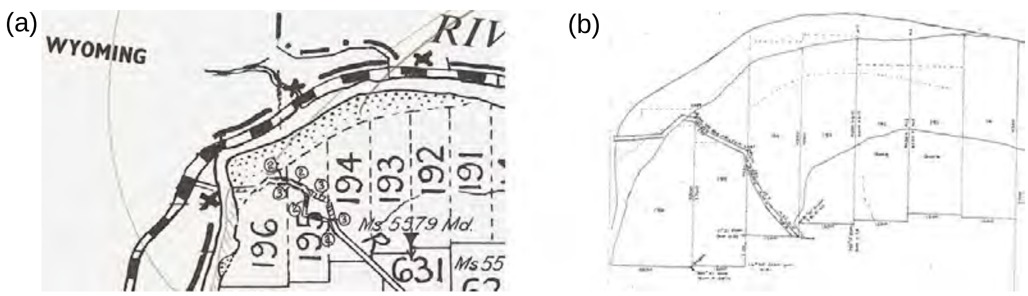

Figure 7: (a) Charting map, and (b) previous plan C.

4.1 The Errors

To determine the error(s) in plan C, an understanding of what constitutes the bank is required, particularly at the time of the surveys. In this example, there is no obvious error. It could also be suggested that there is no purposeful error but only a misguided judgement. Another consideration should be the changes that have occurred throughout time and their influence on where the riparian boundary should be located.

The modern definition of the bank, found originally within the Crown Lands Act, calls for the determination of the mean stage of the stream and the width it requires across the bed to be taken as the bank. This definition did not come into effect until 1931 with the introduction of section 235A of the Crown Lands Consolidation Act 1913. But this definition, for a long time, only pertained to Crown land surveys as the definition was incorporated into the Crown Lands survey directions. The mean stage definition of the bank did not make it into the Real Property survey regulations until much later and was not in the surveying regulations at the time of the survey of plan C. Prior to 1931, there was no clear definition of what constituted the bank. The 1914 NSW directions for licensed surveyors describe the boundary to be a fair limit of the channel, of the watercourse, excluding also shingle beds from the land. As the land below the high bank is river gravel and sand (shingle), albeit grassed, the boundary (if it had been carried out then) would have been the high bank. Prior to 1914, there was no clear direction so the boundary would have been left up to the interpretation of the surveyor at the time. Given the old plans, it is highly probable that the property boundary was at the high bank and not where the newest surveyor locates it.

So, did the bank move from the previous location to where the surveyor for plan C located it? Did the change occur gradually, as is required by the doctrine of accretion and erosion for the boundary to change? When you consider that the bank chosen by the surveyor was along the edge of the water, as it was during the time of survey, it is clear that the old bank had not changed and that the surveyor had chosen another entity to determine the boundary. The entity chosen by the surveyor for the riparian boundary did not conform to the modern definition of the bank as that was later found to be at the rear of the low shingle bed shown on plan C. Essentially, what the surveyor had chosen as the boundary was the edge of the low flow channel (Songberg, 2002, 2012) that existed at the time within the bed of the river.

4.2 The Treasures

The estimation of the amount of treasure depends on interpretations and opinions. If it is considered that the property boundary should remain as it was according to the original survey, then the high bank should have been retained as the boundary. The location of the high bank does not appear to have changed and so all the land in between the high bank and the water channel edge (the new boundary) would be considered as treasure (Figure 8).

The river forming the boundary can run at very high levels, which can change the nature of its banks and bed considerably. Conversely, the channel in which the river usually flows is smaller than the bed of the river and the flow rate not of sufficient force to change the alignment of the channel, or the bank. Only the higher irregular flow can achieve that. Moving the boundary in the manner that has been done in plan C would not have conformed to the doctrine of accretion and erosion. A consequence of moving the boundary would be the impingement of any possible ad medium filum rights of landowners on the other side of the river.

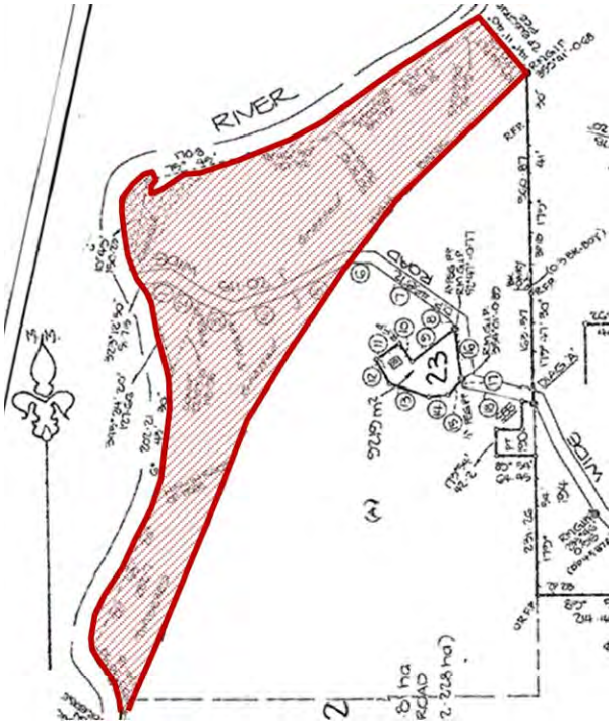

Figure 8: Plan C treasure – consideration 1.

Assuming that the more modern definition of the bank should have been the chosen location of the boundary in both the new and old plans, then only the smaller low level shingle bed would be considered as the treasure (Figure 9). The upstream limit of the low shingle bed is controlled by a concrete bridge structure, and the bank upstream is a few metres high and quite steep. There would be little lateral difference between the low flow water channel and the mean stage bank position. Downstream of the shingle bed, the bank is of similar condition, so the treasure only extends as far as depicted on plan C.

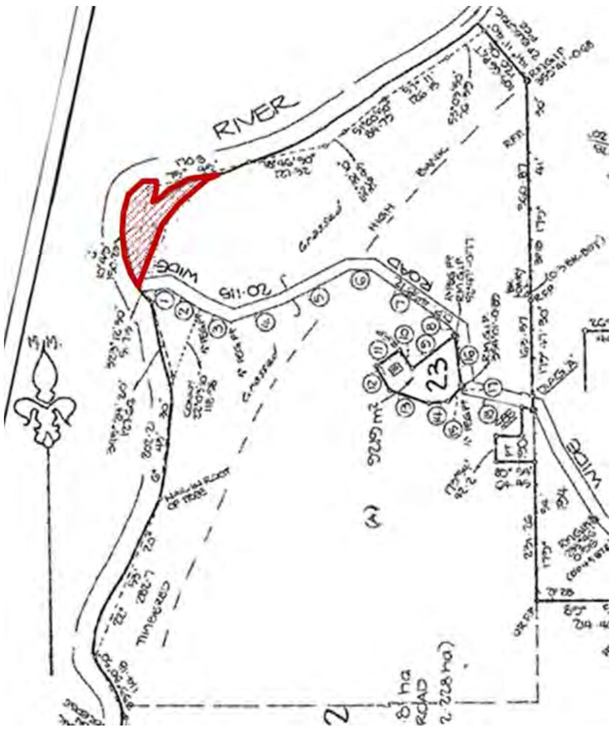

Figure 9: Plan C treasure – consideration 2.

4.3 The Pirates

Unfortunately for the surveying profession, it appears that the pirate in this example is the surveyor. The surveyor changed the boundary entity from the high bank to the low flow channel bank. Even if the surveyor was aiming for the mean stage bank, then their guess was not correct. Furthermore, it seems that compliance with the doctrine of accretion and erosion was also not followed.

Perhaps though, the pirate here could be the difference of opinion between surveyors as to what should be the bank or the riparian boundary of the land. This has been a fundamental issue for all time when it comes to determining the non-tidal riparian boundary. Everyone seems to have a different opinion as to what the bank should be. Introduction of the mean stage definition made no difference to the issue as finding the bank under this definition is impossible unless the surveyor has access to the data from a long-standing stream gauge that is nearby and can be used to determine the quantum of the mean stage.

Maybe the pirates are not the surveyors but rather the rules that govern what the surveyor should use as the boundary. Those rules have changed over time and essentially result in different entities being targeted as the boundary. It is no wonder that the surveyors have differences of opinion as to the location of the bank. Maybe the real pirate is the rules, including those current at the time of writing. Those rules force a surveyor to change the location of the non-tidal boundary from being a bank, of any description or position, to that determined by the mean flow limit of the bed, thus creating hidden treasures.

5 EXAMPLE D (1998)

Pirates and treasures seem to be appearing quite significantly in riparian boundaries. Here is yet another example. The relevant segment of plan D shows a strip of land along the bank of the river, which is identified as lot 141 (Figure 10). Investigating the previous plan, we find that the plan has been compiled from the original portion plan (Figure 11), and a notation on the plan states “the boundaries between lot 139 and lots 141 and 142 are intended to be 20 metres from the bank of the Manning River as at the date of survey of” the original portion plan.

From the portion plan, it is clear that the bank is well defined by a creek traverse, and at the time of survey there is a shingle bed plus a shingle island within the river. The modern surveyor in conducting plan D states on the face of the plan that the location of the riverbank is substantially the same as on the original portion plan. So, it looks like everything is fine and there are no treasures. However, when the banks of the old and new plans are compared, the story is a little different.

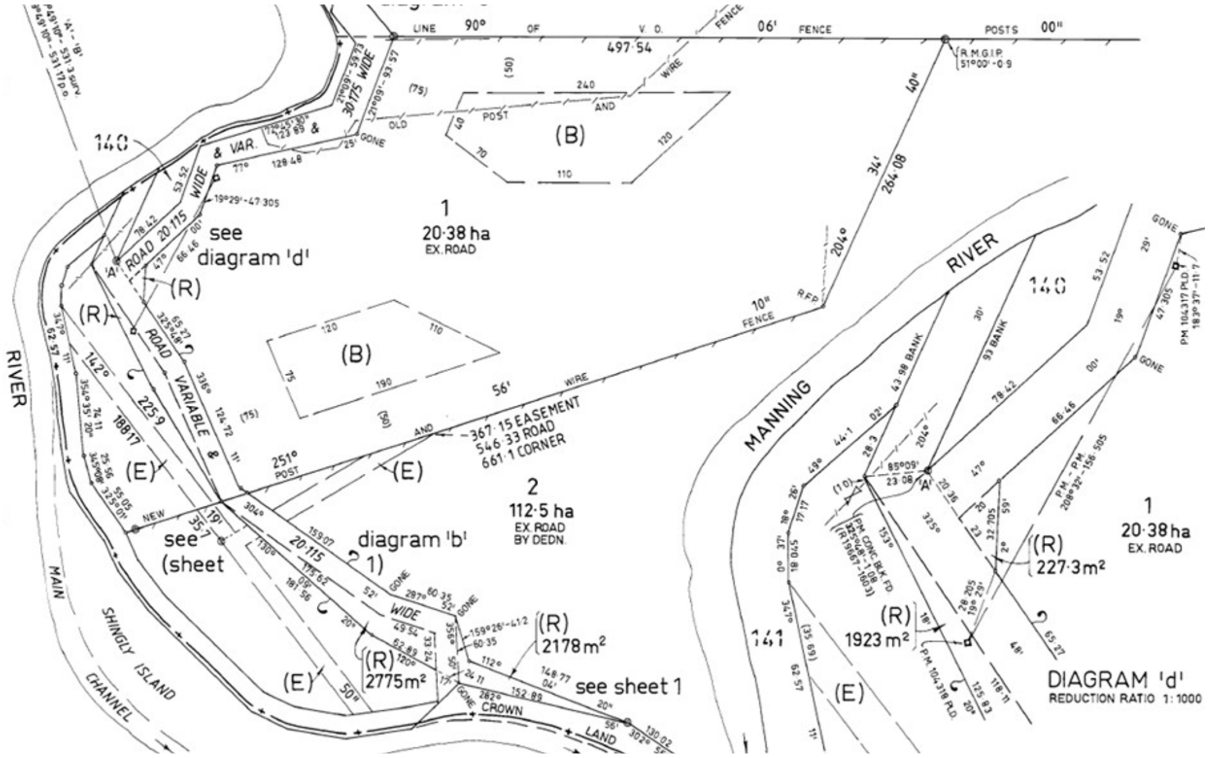

Figure 10: Plan D.

Figure 11: Original portion survey plan D.

With a graphic overlay of the portion plan over plan D (Figure 12), it becomes evident that the landward boundary of the river front strip of land is different between the two plans. There is also a difference between the two bank determinations of the river. Furthermore, the shingle bed evident on the portion plan has disappeared off plan D. On-site examination found that the riverbank chosen by the surveyor was the water's edge of the stream channel evident at the time of survey. The old bank as defined by the portion plan was still in its original location at the back of the shingle bed.

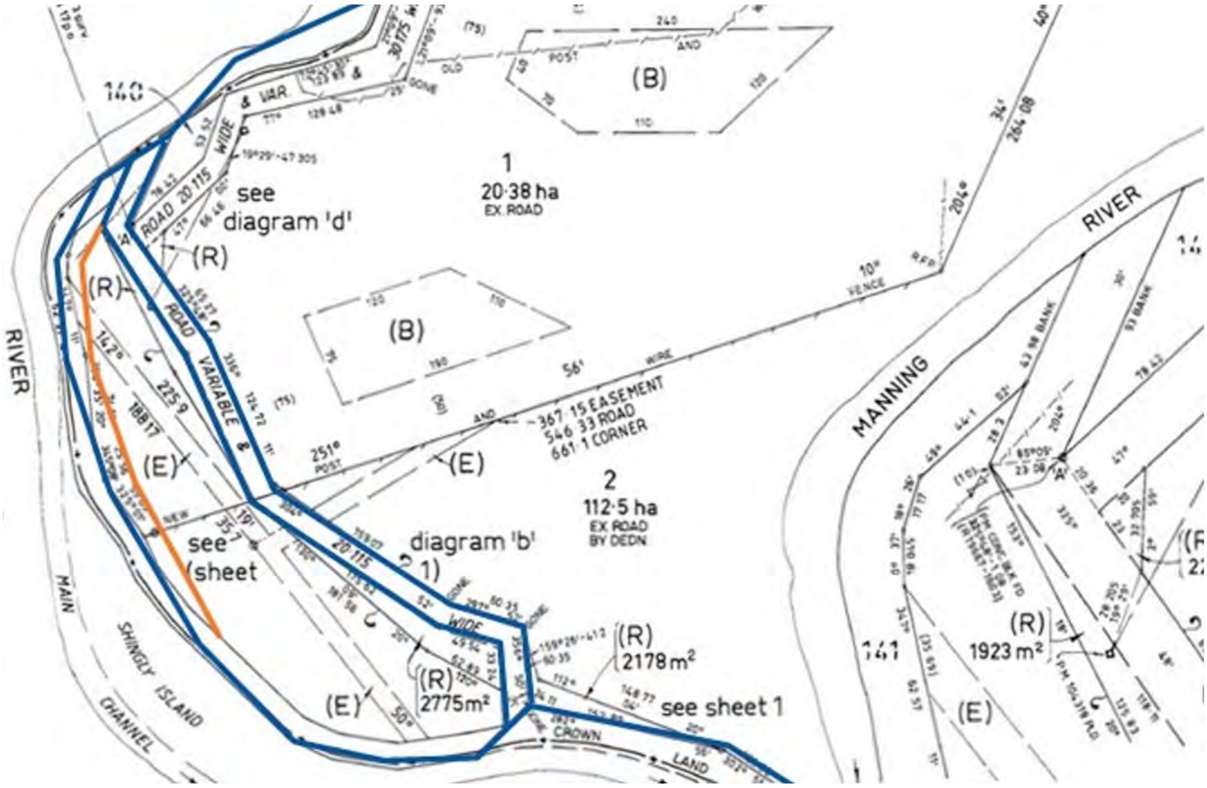

Figure 12: Plan D and portion plan overlay in blue, with the reserve boundary shown in orange.

5.1 The Errors

The error immediately evident is that the surveyor did not comply with the requirements of the landward boundary and did not locate the bank as was defined by the portion plan. Instead, the surveyor chose a different interpretation of that requirement and determined their own bank at the edge of the water.

Consideration of the doctrine of accretion and erosion is not required in this instance because, according to the preceding plan, the boundary was to be fixed from data as at a particular point in time, i.e. the date of the portion survey. The modern mean stage definition of the bank was also not up for consideration, even though the bank was a definition pertaining to Crown land, the strip of land being lot 141.

The judgement of the surveyor as to what constitutes the bank of a non-tidal stream could also be considered as being in error. In this example, as in the previous one, the opinion of the surveyors was that the edge of the water was judged to be the bank of the stream or river. If this is a growing trend, it is no wonder that there are significant differences occurring between old and new definitions of the bank. There has not been a change in the location of the bank but rather a different location, and entity, chosen by the surveyors for the bank.

5.2 The Treasures

Because of the shift in location of the bank, and subsequently a shift in the location of the landward boundary of lot 141, the treasure is the land gained by moving the bank out into the bed of the river (Figure 13).

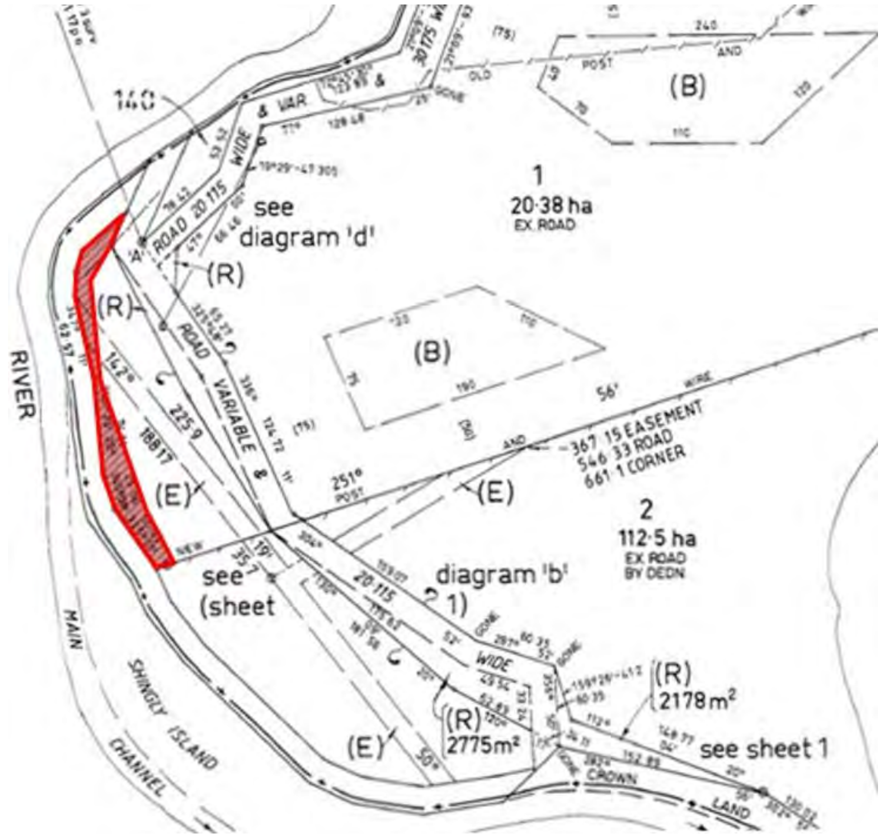

Figure 13: Plan D treasure.

5.3 The Pirates

The first pirate springing to mind is the surveyor. In some respect that identification would be correct as the surveyor did not follow the directions of the previous plan and reinstate the bank as per the original portion plan and then offset the 20 metres to locate the landward boundary of the reserve. Another pirate could be the regulations themselves as at the time there was no requirement for approvals of a non-tidal stream bank. If there were, then the error would have been discovered.

There is also the matter of what surveyors identify or choose as the bank of a non-tidal stream. Similarities between this example and the previous suggest that surveyors may be a little misguided as to what is the bank and how to find it. If the older surveyor chooses the high bank and the newer surveyor chooses the water edge of the usual flow channel, then of course there is going to be a difference in location. This difference of opinion may be the cause of many disagreements as to the location of non-tidal boundaries. As previously mentioned, even the introduction of the mean stage derivation of the bank did not change this difference-of-opinion problem. It seems that every determination of the bank has been and continues to be a guess (Songberg, 2020). It is easy to see that if surveyors have different ideas as to what is and how to locate the bank, then their education may have been different. The idea that the edge of the water of the usual flow channel could be the bank has never been the case, and mathematical analysis suggests that this feature is the edge of the low flow channel found somewhere within the bed of the stream (Songberg, 2002, 2012). So where did surveyors get the opinion that it was the non-tidal boundary? Thus, it is plausible to consider that the educators, not only of surveyors but the law makers as well, could also be considered pirates.

6 EXAMPLE E (2001)

Plan E (Figure 14) covers part of the Crown estate and was created during the development of the Digital Cadastral Database (DCDB), identifying Crown lands for inclusion into the Torrens register. The process did not make Crown land become Torrens title but simply enabled it to be recorded into the register for the developing digital identification of all land parcels. There are many of these parcel identifiers throughout the state.

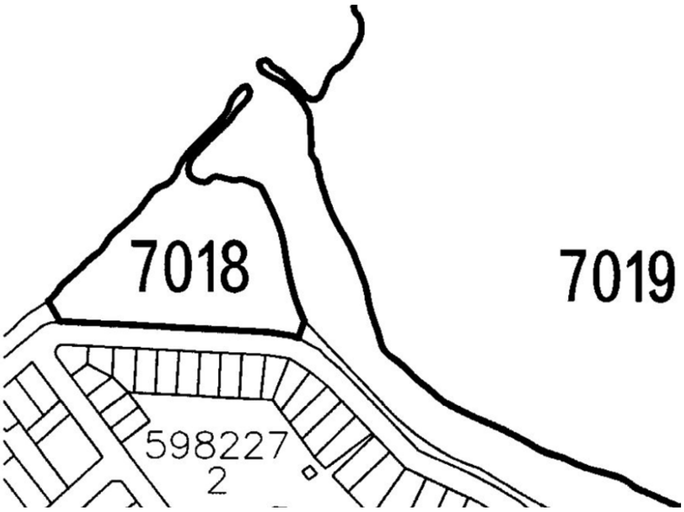

Figure 14: Plan E.

A base assumption is that these plans are correct. Unfortunately in reality, they are too often erroneous. It takes a fair bit of not so in-depth research to show that this plan, i.e. that part pertaining to lot 7018, is erroneous. The plan shows a road between lot 7018 and the land parcels to the south. The road in the location as shown does not exist, although a road does exist in the area but not in this location.

There is an older plan, showing in depth the status of this peninsular of land (Figure 15). This plan shows the changing circumstances of the reservations on the point. Noted on the plan is that the public road is not included in the new reserve and that it is shown to be located within reserve 170 and not against the parcels of land to the south. Checking the gazette for the public road verifies that it should be within the reserve and not against the southern land.

A check of the subdivision plan (Figure 16) creating the lots depicted in plan E shows that, in this instance, the surveyor got it right and identifies the land immediately north of the subdivision as a reserve and not as a road as shown by plan E.

A bitumen road surface around the point within the reserve formerly identified as R170 does exist. But unfortunately, there is also a physical road surface, which is currently used as the through road, located against the northern boundaries of the subdivision lots as shown by plan E. This, however, does not make it a road. In addition, there is the tail pointing north and east out from the top of the point. This point was never part of the land but rather a constructed rock wall that was built during 1901 for the reconstruction of the river entrance.

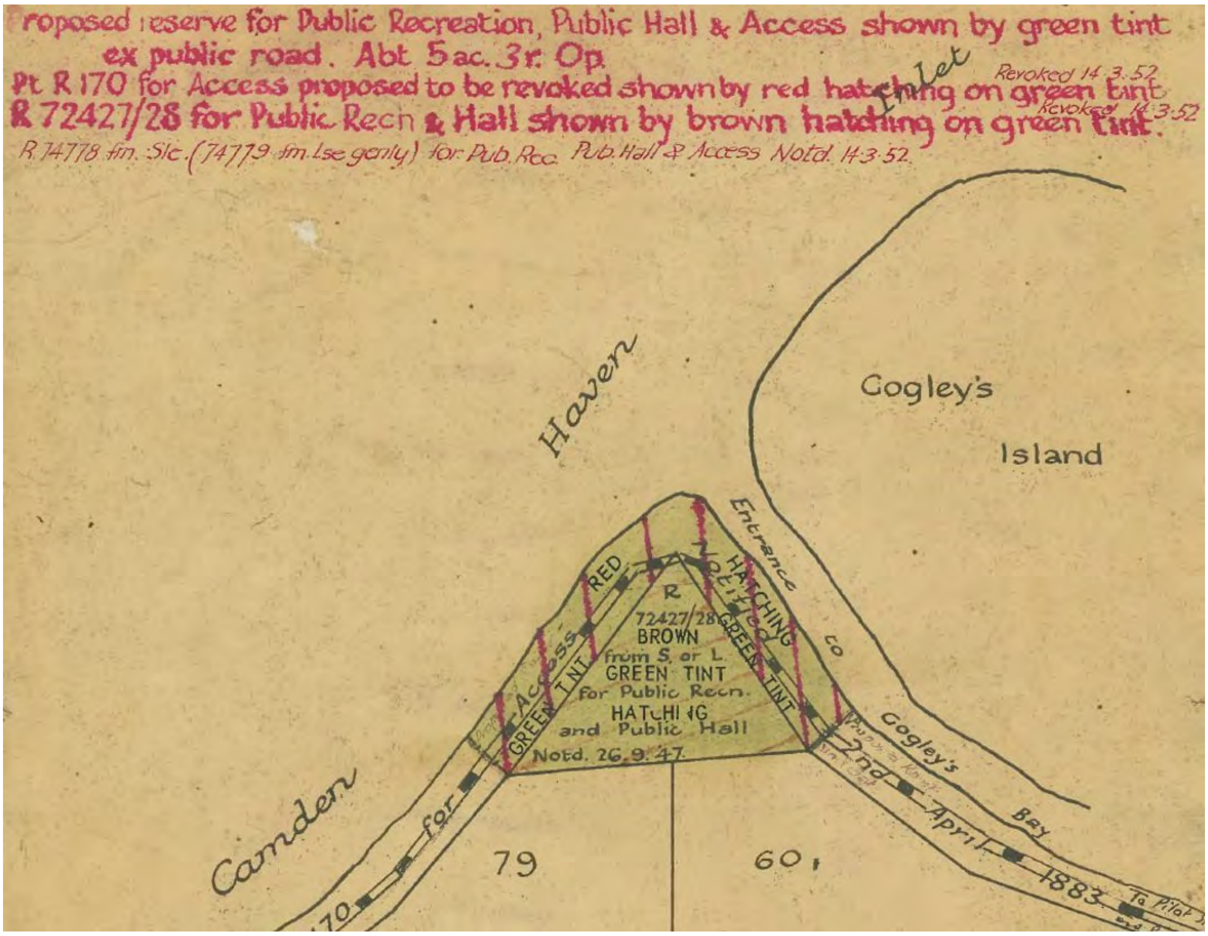

Figure 15: Prior plan to plan E.

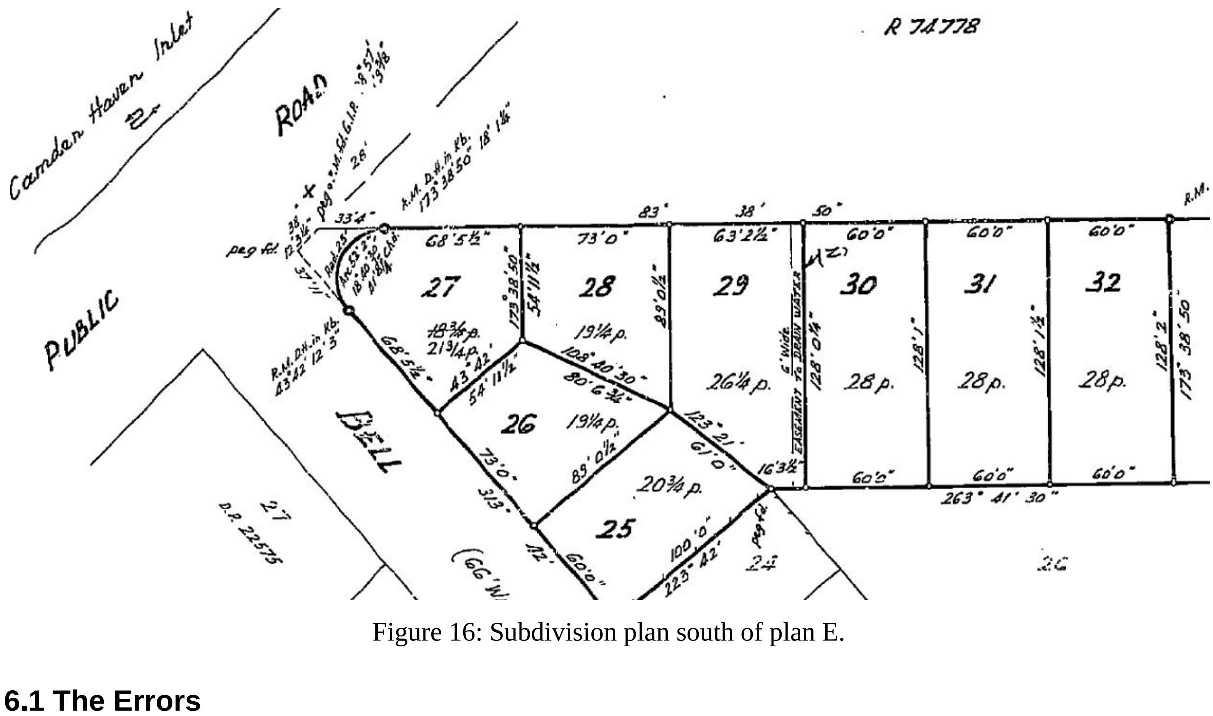

Figure 16: Subdivision plan south of plan E.

6.1 The Errors

The first error that occurred is the drafting of the linework creating lot 7018 by the builders of the mapping component of the DCDB. They were simply wrong. Lines were drawn around anything that was observed despite whether or not it should have been included. Sometimes not even similar features were included. Lot 7019 in plan E included mangrove swamps, constructed rock walls of the new entrance, open water and a small island (Songberg, 2019). The next error is that the linework was not checked for validity. The final error, which is not discernible by just looking at the plan, is that the designation of what the lot entails (i.e. the status of the land) was not verified, and if queried with Crown Lands, the resulting data would be incorrect.

6.2 The Treasures

In this example there are three treasures (Figure 17):

- In red, the apparent road fronting the house lots, which is not a road but part of the reserve. The situation gives the owners of the house lots the belief that they have access to their land from a public road. This belief could be considered a treasure. The reality is that they do not. Their access is through a reserve for public hall, recreation and access.
- In green, the part of lot 7018 that really is the public road and not part of the reserve. The gazettal of the reserve excluded the road, so it is not part of the reserve but instead a public road.
- In blue, the constructed revetment wall built around 1901 for the river entrance reconstruction that is not part of the reserve. The wall should be part of the riverbed if you consider the true status of that feature.

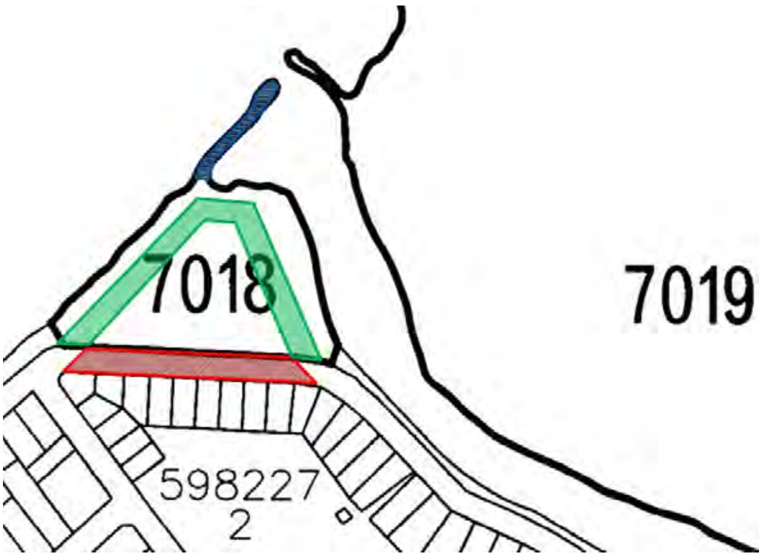

Figure 17: Plan E treasures.

6.3 The Pirates

For once, the surveyor is not one of the pirates. If you consider the surveyor of the subdivision in Figure 16, then it could be said that the surveyor was a purveyor of the truth.

The real pirate in this case is the organisation that constructed the road fronting the houses. The presumption is that it was the local council who built the road, which was on an alignment easier than the one around the point and also removed the physical traffic route away from the recreational components of the reserve. The hall fronts the old road surface and next to it is a trailer parking area for a boat ramp on the other side of the old surface. Despite this being Crown land, local council is the manager of the reserve and most likely within its management rights to realign the through traffic road. However, they did not provide the roadway with the status of a road – it is still part of the reserve.

The other possible pirate could be the verifiers of the Crown estate for not getting the mapping status correct. The creators of the linework in building the digital mapping for the DCDB could also be grouped here as a pirate. Lines were drawn around features without giving due thought as to what should be and what should not be in a lot.

7 EXAMPLE F (2007)

The survey undertaken for plan F (Figures 18 & 19) is quite comprehensive and within itself very good work. However, there is one fundamental problem the surveyor did not foresee, which eventually brought the project unstuck. The land on which the survey was conducted is Crown land, managed through various reserve designations and purposes. Over time, the graphic records of the reserves and their extents became corrupted with the introduction of the DCDB graphics, pushing that corruption into the realm of nothing was right, including the public road depicted in the south to which the survey connects the survey (Songberg, 2019).

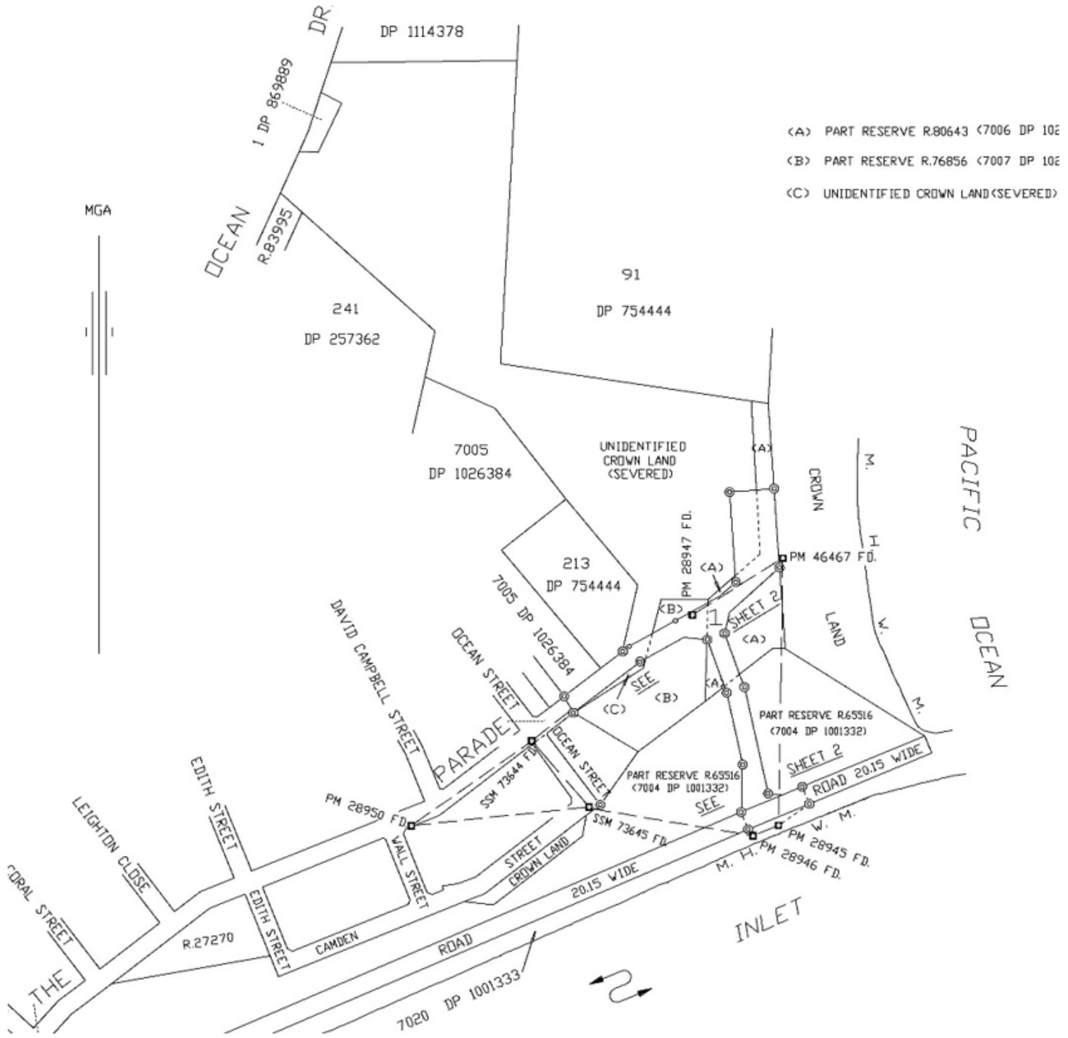

Figure 18: Plan F1.

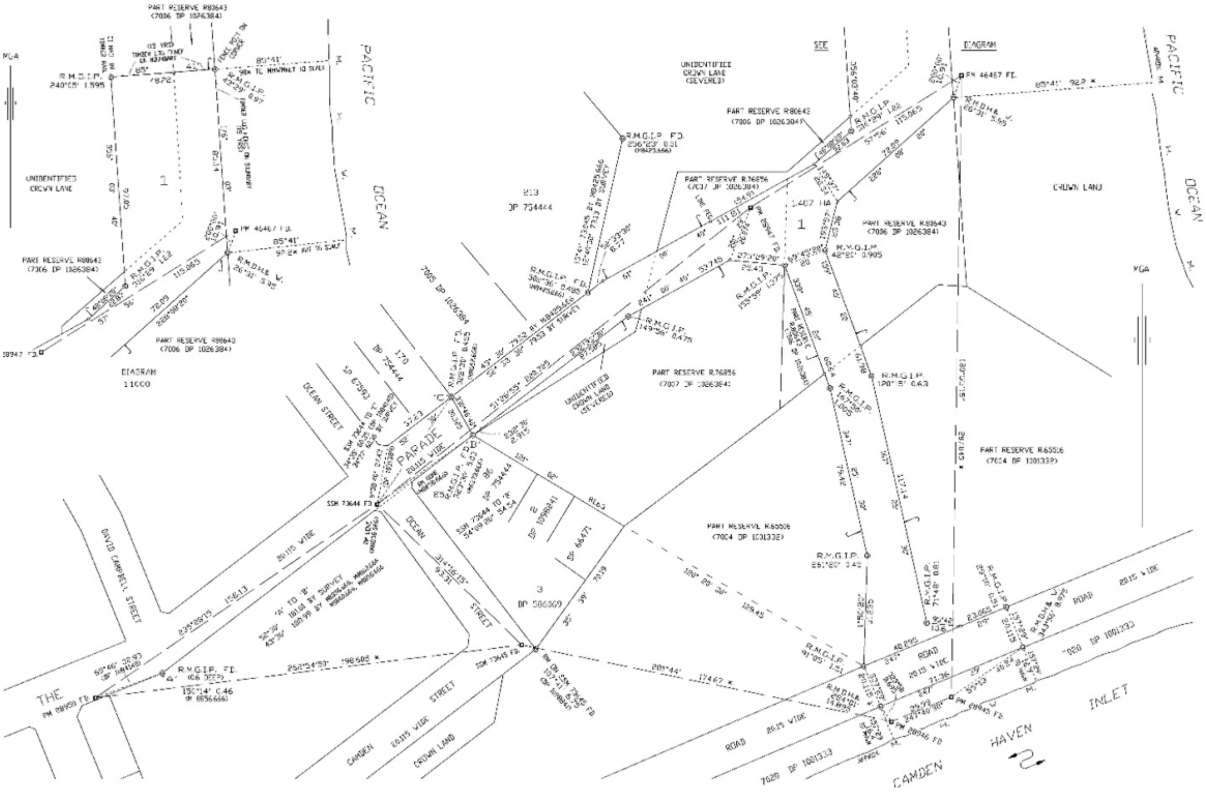

Figure 19: Plan F2.

7.1 The Errors

The fundamental error in this example is the DCDB. It could not be more wrong if it tried. Admittedly, the source of the errors does not fully land on the shoulders of the builders and verifiers of the DCDB across the Crown estate. In this area, the errors have crept in over time and been compounded upon. Mapping of the cadastre, particularly in this area, has been problematic. Unfortunately, errors such as those seen here and in the previous example are quite common when it comes to the Crown lands component of the DCDB. Users of this part of the cadastre, including surveyors, often do not realise that it is prone to errors. A golden rule that should be applied when navigating this part of the cadastral sea is to firstly assume it is wrong. This should be followed by doing the research to prove it is either right or find out what is correct, and then use the end result.

The other error is that the surveyor did not realise that the cadastre was fundamentally corrupt. They scaled, straight from the cadastral mapping, the positioning of the various components and used this as the basis of definition. This made the survey and its impact on the land invalid. The plan thus could not proceed to registration.

7.2 The Treasures

Because this survey did not proceed to registration, there are no buried treasures. But if it had done so, then the treasures would be quite extensive.

7.3 The Pirates

Once again, the pirate tag seems to be gravitating towards the surveyor. Because the plan was never finalised and no treasures were buried in the cadastre, the surveyor could only be considered a wannabe pirate. This was not by choice but by ignorance of the conditions of the cadastre and not validating what they were surveying. Perhaps the real pirates here are the builders, managers, verifiers and validators of the cadastre, particularly the cadastre within the Crown estate.

8 EXAMPLE G (1871)

This example seems to be too old for buried treasure to still exist (Figure 20). After 152 years one would think that any treasure would have eroded into the background or dug up many years ago and dispersed. But that is not the case.

Figure 20: Plan G, the original portion plan.

To understand how a treasure still exists after so much time, a bit of survey plan history that occurred following this plan needs to be understood. On plan G, corners A, B, C and D are marked with reference trees. In 1880, another crown plan is conducted encompassing land to the south and east in a single large portion. That plan locates corners B, C and D but does not investigate corner A. After another 8 years, in 1888, two plans are finalised, covering the village to the northeast of plan G. Both plans are signed by the same surveyor on the same day. Both plans locate corner A but do not investigate any other corner. One of the plans also locates the northern corners of portion 4 to the west of plan G.

The next plan of interest is not until 1913 (Figure 21). This plan locates a peg at corner A and another at corner 1. The surveyor then uses the bearings and distances off plan G and extrapolates eastward the length of line 1-2 and creates a lot. No other marks are found, and no reference marks are placed.

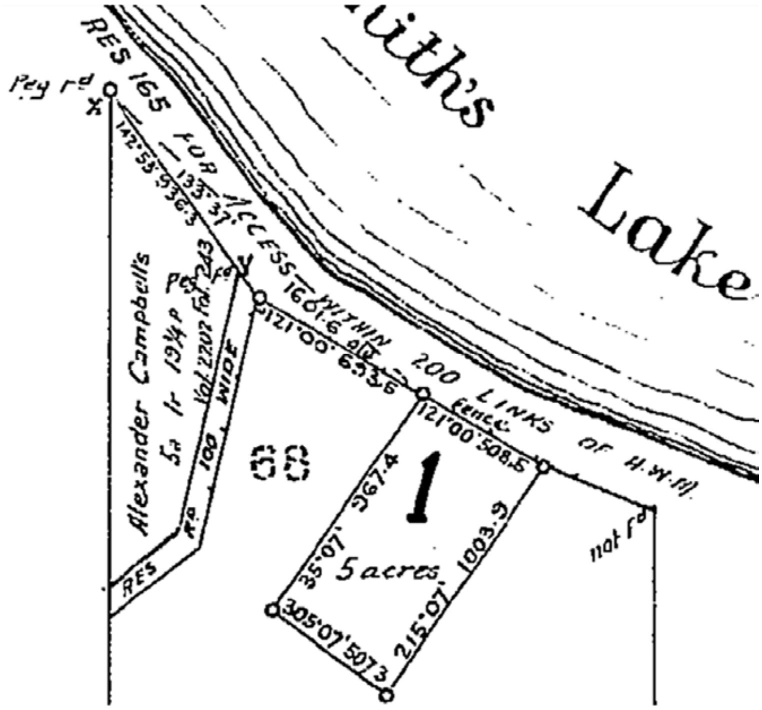

Figure 21: Survey using only plan G for azimuth.

Jump forward another 56 years to 1969, and a new survey subdivides the land to the south and east of plan G. No marks are found from plan G and the location is established from the previous plan dimensions measured up from the south. Reference marks are placed on the alleged B, C and D corners of plan G. An old round fence post, east of corner D, is assumed to be on the northern boundary alignment of the land. But at the same time a fence line is shown a considerable distance, graphically about 20 m, north of the southern boundary of plan G.

Three years later, in 1972, another survey cuts off the top of the north-western part of plan G. This plan finds no marks within plan G and so uses marks found to the northeast within the village plan to establish azimuth and leaves reference marks on each end of the cut-off line. Apparently, the northwest part of plan G is too close to the lake and imposes upon reserve 165 that was created 40 m wide, 13 years after the inception of plan G. That part cut off is incorporated into the reserve.

Another plan in 2013 is produced around the north-eastern corner of portion G, locating the reference marks from the 1972 plan and extending south as far as the north boundary of portion 4. Enough reference marks are found to re-establish the original 1800s relationships between plan G, the village plans and portion 4. Additional reference marks are placed.

The 1972 and 2013 plans have not investigated south and east across plan G, nor have they been connected to the 1969 plan. No one knows that there is a hidden treasure. The newest surveyor to work in the area has not yet registered the intended plan as there is a problem that has been uncovered. After measuring north-south across plan G between reference marks placed by the previous plans, there is an extra 20 m in the western boundary of plan G that should not be there. It appears that a treasure has been uncovered.

8.1 The Errors

The newest surveyor not only finds all the reference marks placed by the 1969 plan but also locates the old fence post noted on that plan east of corner D. The fence shown on the 1969 plan was measured as being 20 m north of the south boundary of plan G and parallel to it.

The connections across plan G to the 1972 and 2013 plans reveal that there is an extra 20 m between the south boundary of plan G and the internal road. The eastern boundary does not have that extra length. The eastern boundary of plan G is found to be essentially confirmed in its length and location as per plan G. The whole of the northeast corner, the village plans, the 1913, 1972 and 2013 plans appear to be too far north by about 20 m when compared to the south boundary of plan G (Figure 22).

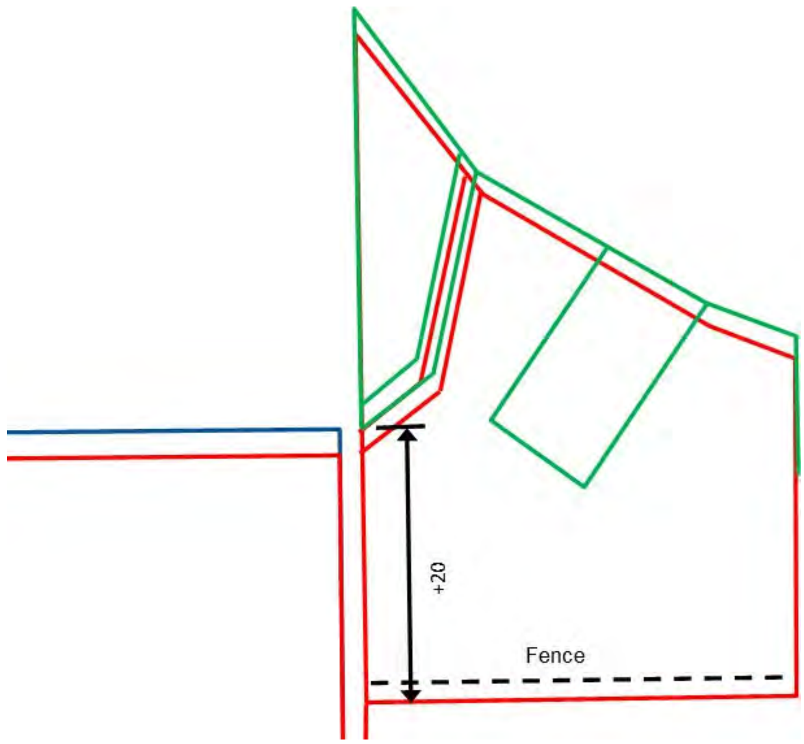

Figure 22: Overlay of (red) plan G with relation to portion 4, (green) 1913 plan tied to shifted NE corner, and (blue) north boundary of portion 4 tied to village plans and NE corner.

8.2 The Treasures

At first glance you would think that there is only a treasure associated with plan G. But wait, there is more…

Perusal of plans associated with portion 4 reveal that there is also an additional 20 m north-south across that parcel. Similar to plan G, portion 4 has been surveyed, in part only, as early as 1947 with pieces taken out. Only the pieces have been surveyed and the residue given as a deduction. Such was repeatedly occurring as late as 2002. But only 5 years later, in 2007, one surveyor does survey the eastern part of the residue, but the east boundary dimension is about 20 longer than the residue deduction. It is apparent that a 20 m wide hiatus or treasure within plan G extends westward into and possibly through portion 4 (Figure 23).

Figure 23: Hiatus treasure within plan G extended west into portion 4.

How far the treasure extends westward is unknown. Whether it passes north or south of the internal parcel is also unknown. It could be that finding the extent is not possible.

Internally within plan G, the 20 m strip does not fully extend to the eastern boundary, which has been established to be the correct dimension north-south and in the correct location to the south boundary of plan G. This would mean that there is no treasure on the east side, unless the fence post found by the 1969 plan was not on the boundary as assumed but too far south by 20 m.

8.3 The Pirates

Unfortunately for our profession, the only pirate is the surveyor or surveyors. Somewhere a 20-metre, or 1-chain, error was made and a hiatus created. It may have been made in the survey of the western boundary of plan G in 1871 but why did it also appear in the portion 4 land? Supposedly the two parcels were connected through the village plans. Was the error made in the south and the 1969 plan, which found no marks around plan G, measured incorrectly when translating dimension up from the south? It would take a lot more investigating to find out.

What is clear is that a mistake was made in the early set-out of the land. A surveyor measured wrong. But the more recent surveyors cannot be totally let off the hook. Until now, no surveyor went that little bit further and measured across plan G. It is as though surveyors only did as little as necessary to get a definition and did not do a little bit extra to fully justify their work. Was the extra 20 m reported from the survey of 2007 of portion 4, or did the surveyor simply make it disappear into the land? There is no notation on the plan to give any indication. The segment west of the road through the portion is left as the residue, so we will never know if the 20 m extended out to the west.

8.4 The Treasure Dispersal

What is unusual about this treasure hunt is the plan carried out in 1913. Because of the shift in the northeast corner 20 m northward, that plan, by the manner in which it was defined, is now hanging out in space (green in Figure 22). Essentially, it is too far north if you consider the relation to the northeast corner of plan G as defined by the 1969 plan. How will the problem be resolved? How will the treasure through plan G be dispersed? That has yet to happen. Maybe the next plan will solve everything with the surveyor sailing to the far horizons, doing that little bit extra, in search of that elusive treasure.

A hiatus can sometimes appear in the cadastre. If that hiatus is an excess of land and subsequently a treasure, then two issues arise. Is that hiatus still within the ownership of the Crown or the previous title beneath the surrounding parcels? Or can the hiatus be dispersed into the surrounding land? In this example, the extra land has been incorporated into the surround of portion 4. It is also likely to be absorbed to the residue of plan G. But if that hiatus is negative to the surrounding land, i.e. parcels overlap, then there is no treasure but a burden and the most likely scenario is that the adjacent parcels accept a loss in land area.

9 EXAMPLE H (2003)

The plan in this example (Figure 24) is not a plan of survey. It is a departmental plan that has been prepared solely for the identification of land and no boundaries have been investigated or surveyed. Anyone would assume that the titling authority would be able to get it right but that is not the case. There is a hidden treasure buried within.

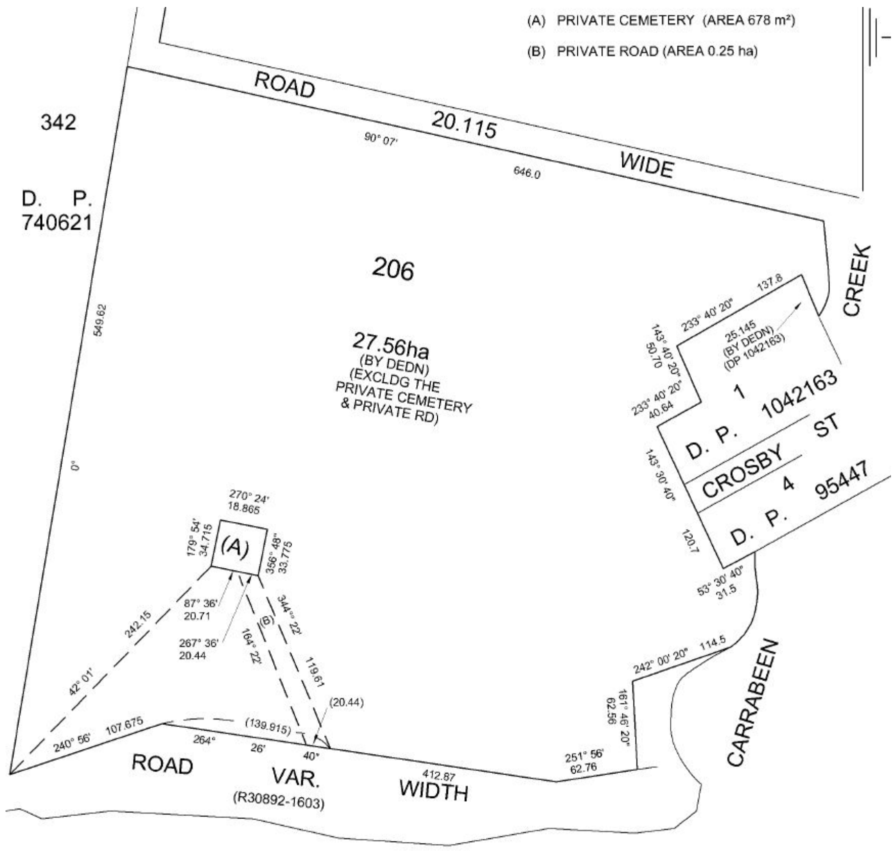

Figure 24: Plan H.

This example provides a very brief insight into the problems that can occur with road status. There have been volumes written on road status and the topic warrants more than a conference paper itself. This is just a snippet showing where hidden treasure lays.

A road is not just a road, as there is a layer of hierarchy that regularly confuses people, leading to all sorts of problems. The three most common road status identifiers that are easiest to understand are Crown, council and main (highways and motorways). All are public roads, but the road authority differs. Crown Lands administers Crown roads, council of course administers council roads, and the state roads authority administers the main roads. There are all sorts of additional status layers and issues within each of these three divisions.

Crown roads are generally simple in that they either exist or do not. Council roads can appear to exist as they are shown on the charting maps but the actions to create the road have not been completed, so in effect the road does not exist. Main roads can have controlled access limitations, so that even though motorists can use the road, property owners may not be able to access them across side boundaries. There may even be a toll on the road that has to be paid to use it.

A physical road might exist, but it does not have the status of road, as was seen in examples E and F. There are many instances throughout the state where trafficable ways are used frequently by the public or property owners but, in reality, have no status of road. The reverse also occurs, especially with Crown roads which have never been constructed. They are often referred to as paper roads.

Then there are private roads. Sometimes these are not roads but instead are rights of ways, which pass through private land giving access to another parcel or parcels. There is no public rights to these roads, only the parties identified in the instrument that created them have access to them. There are also roads that were created out of private subdivisions that have not been dedicated to council as a public road during the process of the subdivision. This issue does not arise in modern subdivisions, but in older ones the dedication of the byways to the public as road sometimes did not occur. That left the status of the thoroughfare, if it was being used, as being a private road. The term ‘private road’ might not even be correct as the real status could be ‘remnant of title’. The owner of the land, if they still exist, out of which the subdivision was created, would technically still own the thoroughfare.

9.1 The Errors

The error in plan H is the status of the road marked (B) private road. It is instead a council public road, and how to work this out is not simple as there is no plan that will provide the necessary information. The subdivision which created lot 206 is a very old private subdivision. The land was part of the Australian Agricultural Company (AACo) grant that ran from Port Stephens north to the Manning River. When the company divested itself of the land it was divided into parishes, similar to Crown parishes, and subdivided within each parish. Giving access to each parcel was a network of roads. Whether or not any particular road has the status of private road, public road or remnant of title will depend on the history of the road itself. Each case can only be determined on its own merits.

In this instance, the land was within what was the council boundaries of Stroud Shire. In 1908, the council, through a series of correspondence, sought from the AACo the roads within the boundaries of the shire to be given unto council as public roads. There exists, though not well known or publicised, a list of parishes and roads within each parish that the AACo agreed with council to be given as public roads. The road marked (B) is one of the roads on that list.

9.2 The Treasures

Because of the status error, there would be a belief that the road belongs to a private owner. Someone, not necessarily the owner of lot 206, has a parcel of land or a hidden treasure. Council might even consider that it does not have any need to do any administrative activity on the road. A small bonus that would lessen, just a little, all the work that needs to be done. This is the treasure of not having to take an action.

9.3 The Pirates

In this instance, the surveyor cannot be considered as being one of the pirates. No surveyor had anything to do with this plan. A surveyor has instead done the required investigatory work and can be considered the purveyor of the truth. They found out the road is not a hidden treasure and that the plan has to be rectified to disperse the treasure where it should be, i.e. in the hands of council as a public road.

The pirates in this case are, in the first instance, the departmental authority who prepared the plan without the full set of information to ensure it was correct. The second pirate could be the recorders of such historical information for not ensuring that it was appropriately transferred to the cadastre. Missing or erroneous cadastral information is not a common problem, but it does happen (examples E and F). Just because something is recorded in a certain manner does not necessarily mean that it is correct. This example just happened to be about a road.

10 CONCLUDING REMARKS

Using just a few examples, this paper has uncovered many treasures that were hidden in the cadastre. Unless you have the appropriate experience, these treasures are not easy to find and can lay hidden for a long time or may be buried forever. The reasons why these treasures exist in the cadastre are not related to the pirate activities of individuals as the theme of the conference and the title of this paper may suggest. Instead, the term pirates refers to the circumstances that have brought about errors of not having a complete understanding of the situation or the variables that are involved in the mapping and creation of the cadastre.

When re-examining the examples presented, it is clear that these errors have mostly occurred inadvertently through misguided beliefs or misunderstanding by all parties involved in the cadastral process rather than through deliberate acts of piracy. So, the term pirates can be loosely cast towards everyone from the educators of surveyors to the individual surveyor right through to the regulators and managers of the cadastral processes. Even the survey practice regulations themselves can loosely be considered one of the pirates, as trying to satisfy their directions can lead to unintended consequences (Songberg, 2021) and even create buried treasure. Perhaps the real pirate is the practice of accepting what is presented as being correct without first verifying the validity of that information.

These examples and their associated buried treasures are just a few of the many that do exist within the seemingly calm cadastral sea. Just how much buried treasure there is and how rough this makes the cadastre is unknown. Unfortunately, the pirates are still roaming blissfully unaware of what they are leaving behind and sometimes compounding the errors that have been created. Every surveyor should be conversant with the principle of adopting an azimuth from two points, but it needs to be validated to a third. The minefield of cadastral information is no different. Perhaps, with due diligence and the required skills, the treasures can be unearthed, the cadastre calmed, and the pirates sent sailing for home port and retirement, never to bury another treasure.

11 FOOTNOTE

In putting this paper together, real examples were used. To create fictional situations would have been pointless as a particular scenario might never have occurred. At the least, the reader is now aware that these occurrences do exist in the cadastre. The author has tried to limit the identification of individuals as much as possible and apologises to anyone who believes that a finger was pointed at them to declare fault. This paper is not intended to lay blame or accuse anyone of wrongdoing. We all make mistakes, such is life. The primary purpose of this paper is education. In seeing the results of what can happen when these and similar mistakes occur, perhaps it will stop them from happening again. If that is an outcome of this paper, then the objective has been achieved. Individual cases just happen to have drawn the short straw to ‘volunteer’ as an educational aid.

ACKNOWLEDGEMENT

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Understanding Old Survey Plans and Field Notes in Surveying Practice

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ABSTRACT

Many surveyors, particularly in regional areas, are required to redefine boundaries which have been measured with link chains and circumferentors. These instruments were phased out by about 1890, when it was mandated that theodolites were required to obtain bearings and steel bands replaced link chains. The interpretation of plans of old surveys marked "bearings by circumferentor" require a clear knowledge and understanding of the practice and use of these instruments. This paper outlines these methods and explains how to interpret the resulting survey plans. Also, the field notes for these surveys were generally known as column notes of which there were many variations. The use of column notes was almost universal in surveys from the 1830s. Therefore, there were many surveys using these notes and, particularly in non-metropolitan areas where no recent development has taken place, they are the last surveys of many properties. This paper explains this form of field notes and the method of interpreting these notes. Reinstating the boundaries of a plan of survey made with a circumferentor requires an understanding of the operation and methods of establishing bearings determined with these instruments. The most important feature of the circumferentor is that it only measures angles, not bearings. Acknowledging the sparse (and potentially erroneous) existing literature on the reinstatement of boundaries established by circumferentor, this paper describes the correct method of redefining these boundaries. Since the field notes of all Crown surveys are recorded in NSW Government archives, they are readily available. It is hoped that this contribution will help surveyors make sense of historical survey information in the modern era of surveying.

KEYWORDS: *Cadastral plans, circumferentor, chain, column notes, boundary surveys.*

1 INTRODUCTION

This paper aims to be of use and assistance to surveyors needing to redefine boundaries in plans of survey done between 1788 and 1888. Most of these surveys relied on bearings established with a circumferentor and distance measurements by a Gunter's chain. In heavily populated areas, such as the County of Cumberland, there would be very few parcels of land which have not been redefined by modern survey methods. However, further away from the population centre of Greater Sydney, there are many titles based on surveys made with circumferentor and chains. To interpret these plans, an understanding of the operation of a circumferentor and chains is essential. Additionally, it is of little use to understand how these instruments were used if it is not known how to locate relevant field notes and then how to interpret them. The purpose of this paper is to satisfy this need.

2 THE GUNTER'S CHAIN

Almost all surveyors are familiar with these measuring devices, having seen them in museums and collections of surveying equipment. Note the chainmen using a Gunter's chain in the painting shown in Figure 1.

Figure 1: Surveyors (1865) by S.T. Gill, courtesy of National Gallery of Victoria (NGV, 2023).

Artist S.T. Gill used considerable artistic licence in order to show all activities together in one painting. Obviously, the axeman would not be so close to the instrument. Also, the axe, Gunter's chain and nearby wagon would add to local natural ironstone in the vicinity, all of which would distort the measurements.

3 CIRCUMFERENTOR

Very few surveyors have had the opportunity to examine one of these instruments in detail and fewer still have actually operated such an instrument (Figure 2). A circumferentor only measures angles because 'magnetic variation' differs from place to place. Therefore, it is essential that the instrument is set on the bearing of the 'datum line of azimuth' as the starting point of the survey. To locate an old boundary as defined by a circumferentor using modern equipment, the distance measured as shown on the plan as the measurement with Gunter's chain should be set out.

It must be noted that, during the century that these instruments were used, there were many instructions authorising additional land to be allowed to ensure that no boundary was short of its nominated length.

Figure 2: Circumferentor.

Before moving any instruments, an investigation should be made for any evidence of marking along the line just measured. In many instances, of course, there could be very old fences in the vicinity. An examination of the corner just re-established should be made, and an expectation should be that the relevant corner could be further than the stated distance of that boundary to allow for any authorised excess.

If no evidence of pegs, blazed trees or fencing is found, the next line on the plan should be measured, ensuring that the angle shown on the plan is used and not the bearing. This method needs to be replicated until some evidence of old boundaries is located. A difficulty will exist where the boundary being measured was not a property boundary in an original holding. The relevance of this is that many Crown portions were amassed together, forming an operational farm or station.

In many instances, most (if not all) boundaries of Crown portions were never fenced because they formed only a part of larger properties containing several to upwards of 100 individual portions. The expectation would be that only the external boundaries of very large properties (made up of many portions) would have been fenced. Therefore, an examination of the history of the holding is essential.

4 FIELD NOTES

Figures 3-14 show different examples of almanacs, field notes and the resulting plans of survey. Since the field notes of all Crown surveys are recorded in NSW Government archives, they are readily available. The use of column field notes was almost universal in surveys from the 1830s. In order to make sense of it all, it is necessary to understand the method used by the original surveyor. In particular, note the accurately drawn sketch of the final survey (Figures 8 & 10). These plans show ridges, watercourses and other useful details with considerable accuracy. These details are very useful in locating old survey marks and fences.

After 1890, it was mandated that all survey bearings be completed with theodolites and steel bands replaced link chains, so these instruments were phased out. Nevertheless, particularly in non-metropolitan areas where no recent development has taken place, surveys using link chains and circumferentors are still the last surveys of many properties.

114 THE SURVEYOR. AUG. 31, 1916.

ASTRONOMICAL NOTES FOR SEPT.-OCT., 1916.

Culminations.

NORTH OF ZENITH.

Star.	Mag.	Mean R.A. H. M. S.	Mean Dec. ° ′ ″
α Aquilæ (Altaia) … … …	0·9	19 46 44	N. 8 39 0
γ Cygni … … … …	2·3	20 19 15	,, 39 59 38
ε Pegasi (Enif) … … …	2·5	21 40 7	,, 9 29 46
α Pegasi (Markab) … … …	2·6	23 0 39	,, 14 45 40
α Cygni (Deneb) … … …	1·3	20 38 37	,, 44 59 12
α Andromedæ (Alpheratz) … …	2·2	0 4 7	,, 28 38 5

CIRCUMPOLAR.

Star.	Mag.	Mean R.A. H. M. S.	Mean Dec. ° ′ ″
(Upper.)			
δ Pavonis … … … …	3·6	20 0 37	S. 66 23 58
β Pavonis … … … …	3·6	20 37 32	,, 66 30 24
α Toucani … … … …	2·9	22 12 52	,, 60 40 34
(Lower.)			
β Argûs … … … …	1·8	9 12 15	,, 69 22 10
θ Argûs … … … …	3·0	10 39 56	,, 63 57 22
λ Centauri … … … …	3·3	11 31 54	,, 62 33 30

Elongations.

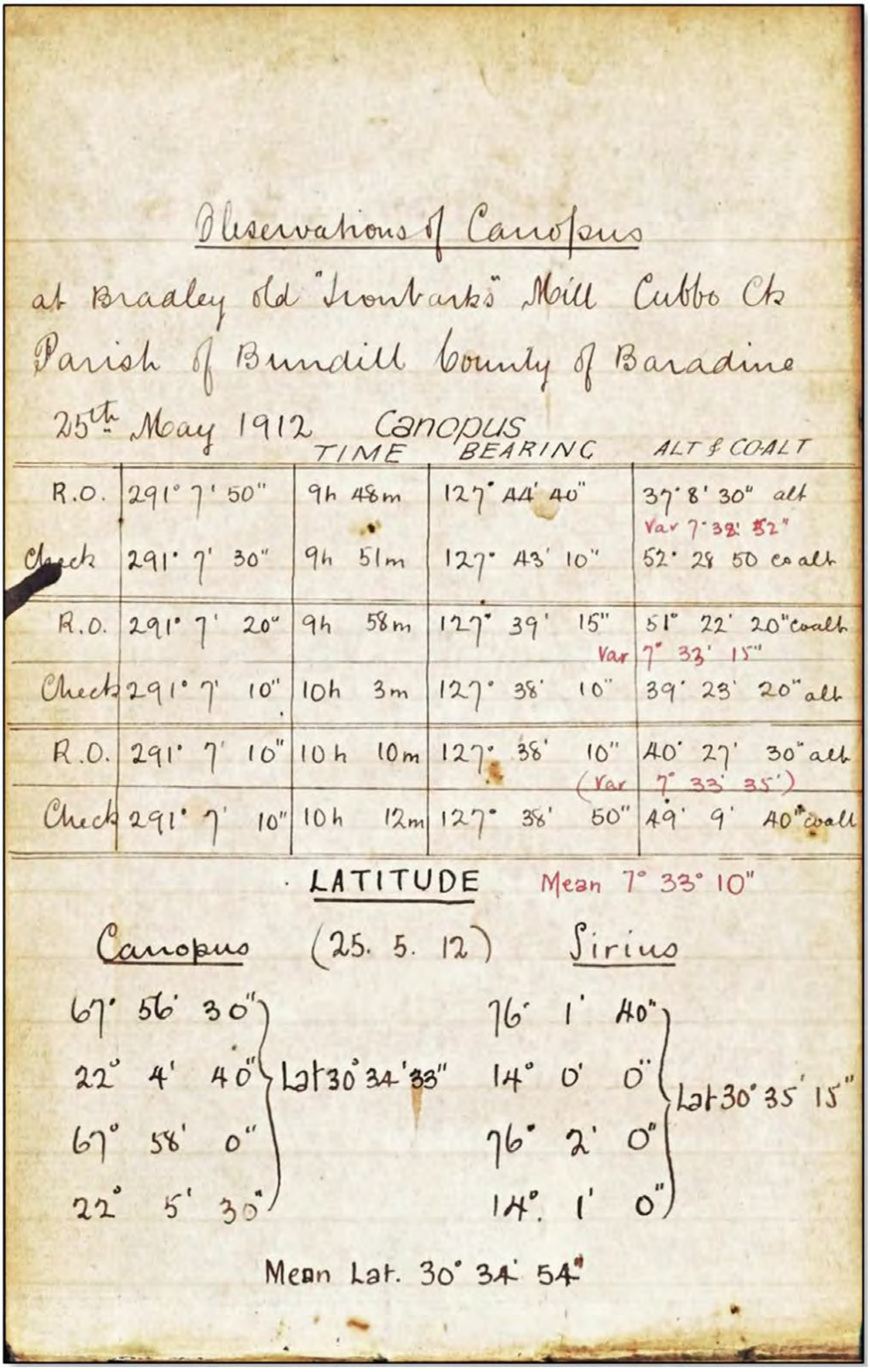
WESTERLY.

Star.	Mag.	Mean R.A. H. M. S.	Mean Dec. ° ′ ″
β Centauri … … … …	0·9	13 57 54	S. 59 58 28
α Centauri … … … …	0·3	14 33 55	,, 60 29 38
α Triang. Aust. … … …	1·9	16 39 50	,, 68 52 54
α Pavonis … … … …	2·1	20 19 7	,, 57 0 20
EASTERLY.			
β Hydri … … … …	2·9	0 21 31	,, 77 43 16
α Eridani (Achernar)… … …	0·6	1 34 40	,, 57 39 19
γ Hydri … … … …	3·2	3 48 44	,, 74 29 18
α Gruis … … … …	2·2	22 3 2	,, 47 21 54

Local Sidereal Time at Mean Noon. 10hrs. E. Long.

	HRS.	MIN.	SECS.		HRS.	MIN.	SECS.
Sept. 1	10	39	37·5	October 1	12	37	54·1
5	10	55	23·8	5	12	53	40·4
10	11	15	6·6	10	13	13	23·1
15	11	34	49·3	15	13	33	5·9
20	11	54	32·1	20	13	52	48·7
25	12	14	14·8	25	14	12	31·5
30	12	33	57·6	30	14	32	14·2

Figure 3: Extracts from a nautical almanac showing only those stars relevant to surveyors (from *The Surveyor*, 31 August 1916).



Observations of Canopus

at Bradley old "Ironbarks" Mill Cubbo Ck
Parish of Bundill County of Baradine

25th May 1912 Canopus

		TIME	BEARING	ALT & COALT
R.O.	291° 7' 50"	9h 48m	127° 44' 40"	37° 8' 30" alt
				Var 7° 32' 52"
Check	291° 7' 30"	9h 51m	127° 43' 10"	52° 28 50 co alt
R.O.	291° 7' 20"	9h 58m	127° 39' 15"	51° 22' 20" coalt
			Var	7° 33' 15"
Check	291° 7' 10"	10h 3m	127° 38' 10"	39° 23' 20" alt
R.O.	291° 7' 10"	10h 10m	127° 38' 10"	40° 27' 30" alt
			(Var	7° 33' 35')
Check	291° 7' 10"	10h 12m	127° 38' 50"	49° 9' 40" coalt

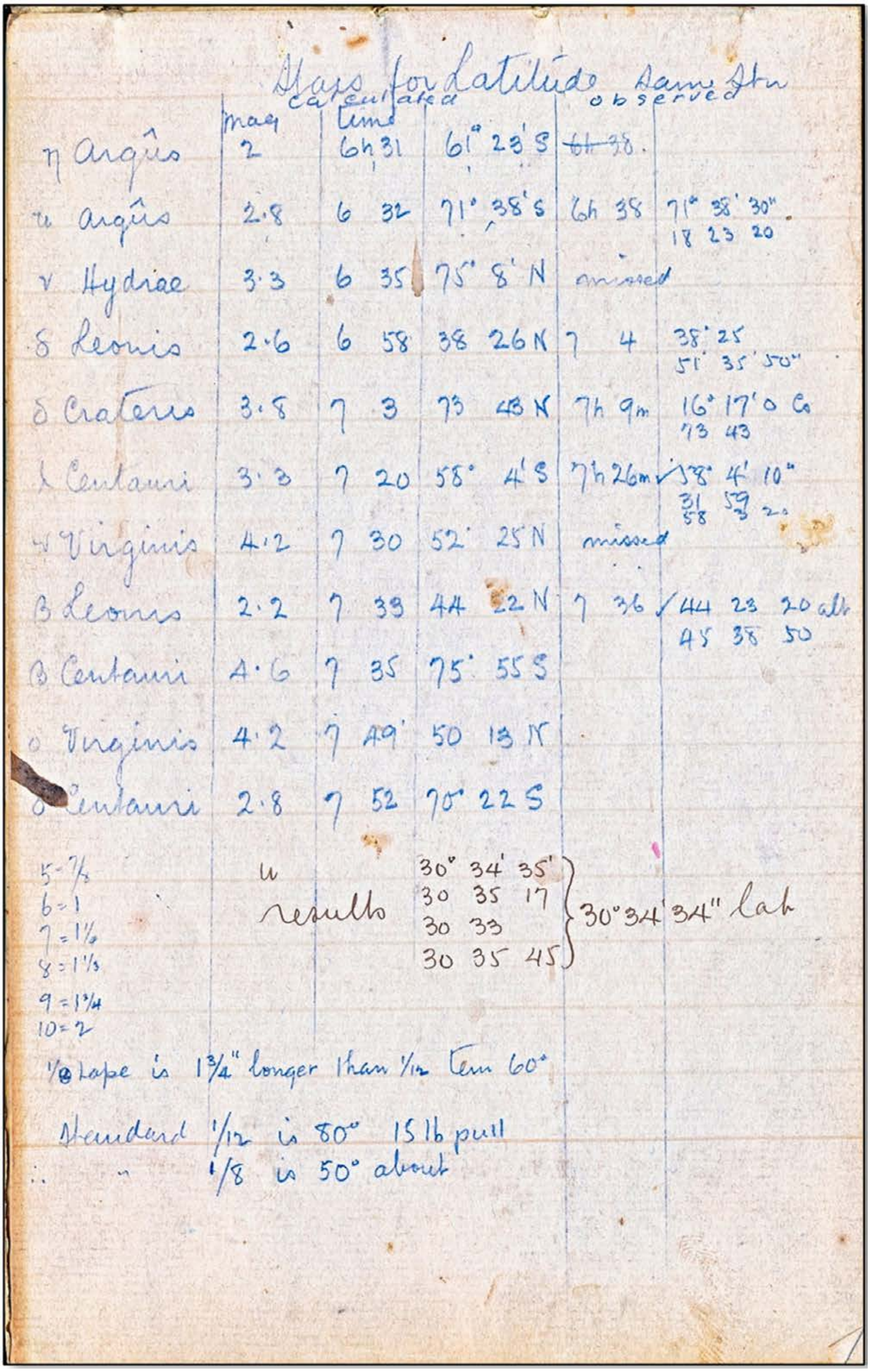
LATITUDE Mean 7° 33° 10"

Canopus (25. 5. 12) Sirius

Canopus		Sirius	
67° 56' 30"	Lat 30° 34' 33"	76° 1' 40"	Lat 30° 35' 15"
22° 4' 40"		14° 0' 0"	
67° 58' 0"		76° 2' 0"	
22° 5' 30"		14°. 1' 0"	

Mean Lat. 30° 34' 54"

Figure 4: Observations of Canopus.



Stars for Latitude Lamb Stn

	mag	time	calculated	observed	
η Argûs	2	6h 31	61° 23' S	~~6h 38~~.	
ι Argûs	2.8	6 32	71° 38' S	6h 38	71° 38' 30" 18 23 20
ν Hydrae	3.3	6 35	75° 8' N	missed	
δ Leonis	2.6	6 58	38 26 N	7 4	38° 25 51' 35' 50"
δ Crateris	3.8	7 3	73 43 N	7h 9m	16° 17' 0 Co 73 43
λ Centauri	3.3	7 20	58° 4' S	7h 26m	58° 4' 10" 31 59 58 3 20
ν Virginis	4.2	7 30	52° 25 N	missed	
β Leonis	2.2	7 33	44 22 N	7 36	44 23 20 alt 45 38 50
β Centauri	4.6	7 35	75° 55 S		
o Virginis	4.2	7 49'	50 13 N		
δ Centauri	2.8	7 52	70° 22 S		

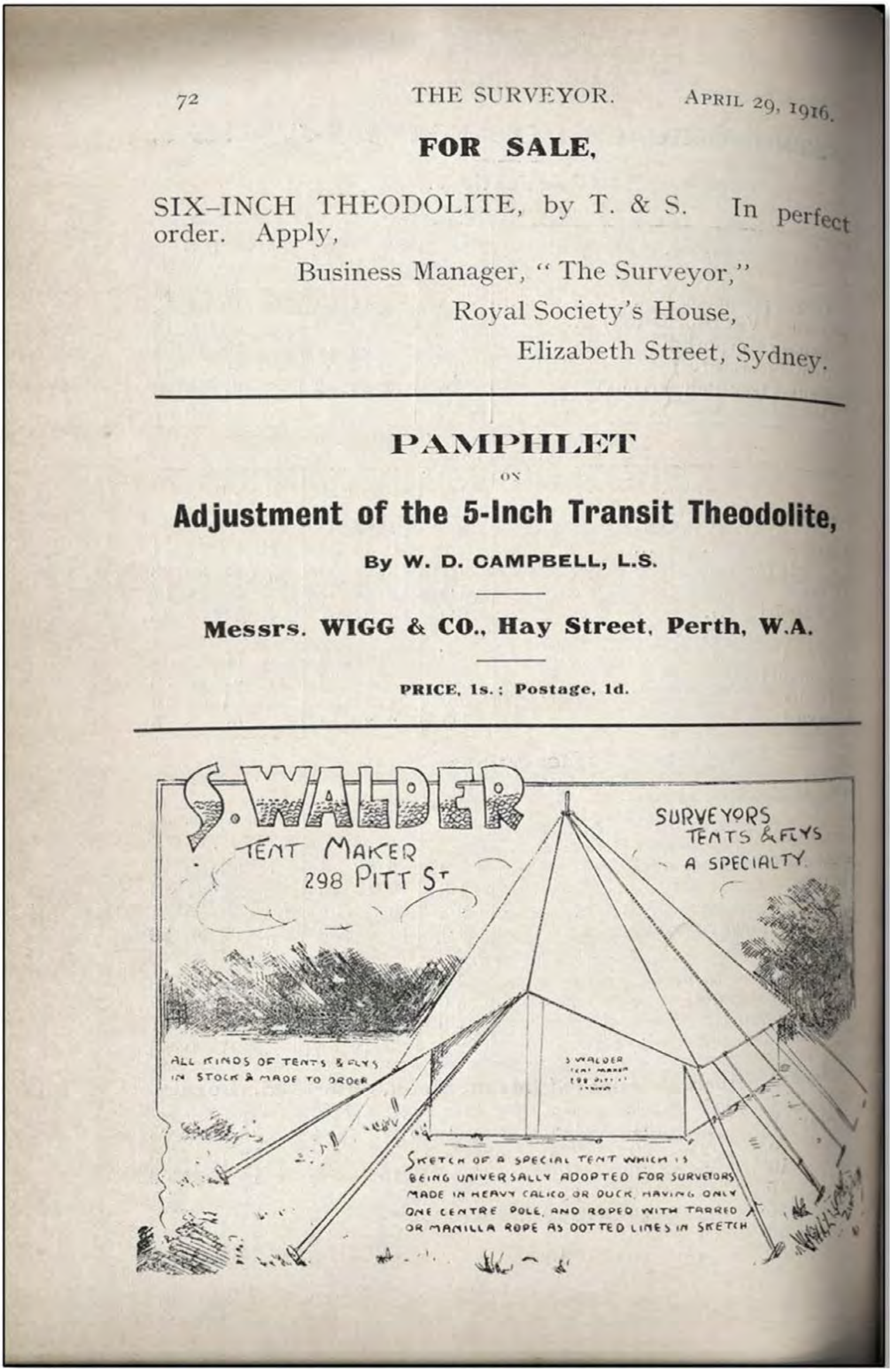
5 = ½
6 = 1
7 = 1⅙
8 = 1⅓
9 = 1¾
10 = 2

results
30° 34' 35'
30 35 17
30 33
30 35 45
} 30° 34' 34" lat

⅛ tape is 1¾" longer than 1/12 ten 60°

Standard 1/12 is 80° 15 lb pull
∴ " 1/8 is 50° about

Figure 5: Stars for latitude.



72 THE SURVEYOR. APRIL 29, 1916.

FOR SALE,

SIX–INCH THEODOLITE, by T. & S. In perfect order. Apply,

Business Manager, " The Surveyor,"
Royal Society's House,
Elizabeth Street, Sydney.

PAMPHLET

ON

Adjustment of the 5-Inch Transit Theodolite,

By W. D. CAMPBELL, L.S.

Messrs. WIGG & CO., Hay Street, Perth, W.A.

PRICE, 1s.; Postage, 1d.

Figure 6: Advertisements in *The Surveyor*, 29 April 1916.

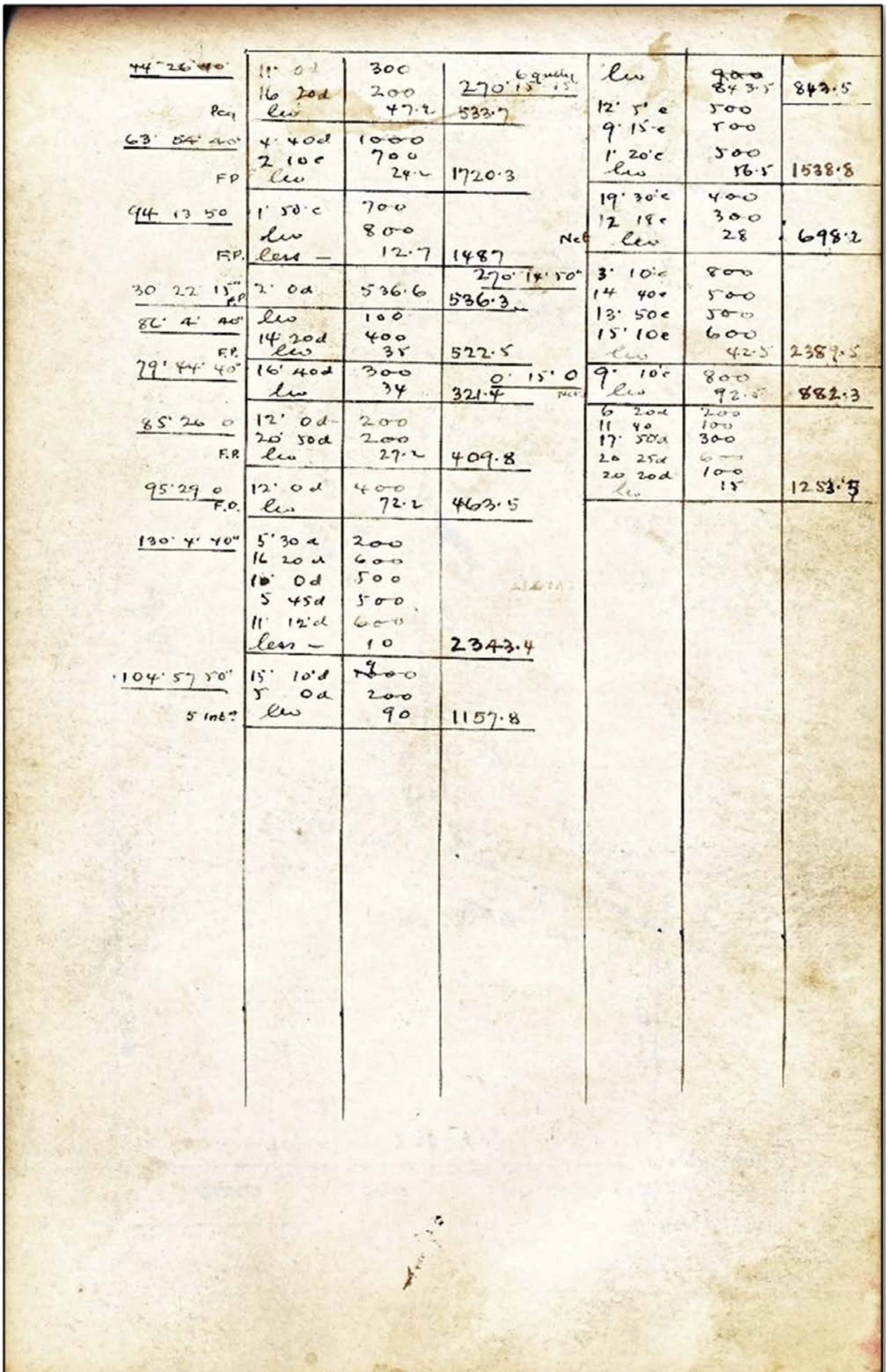


Figure 7: Column field notes.

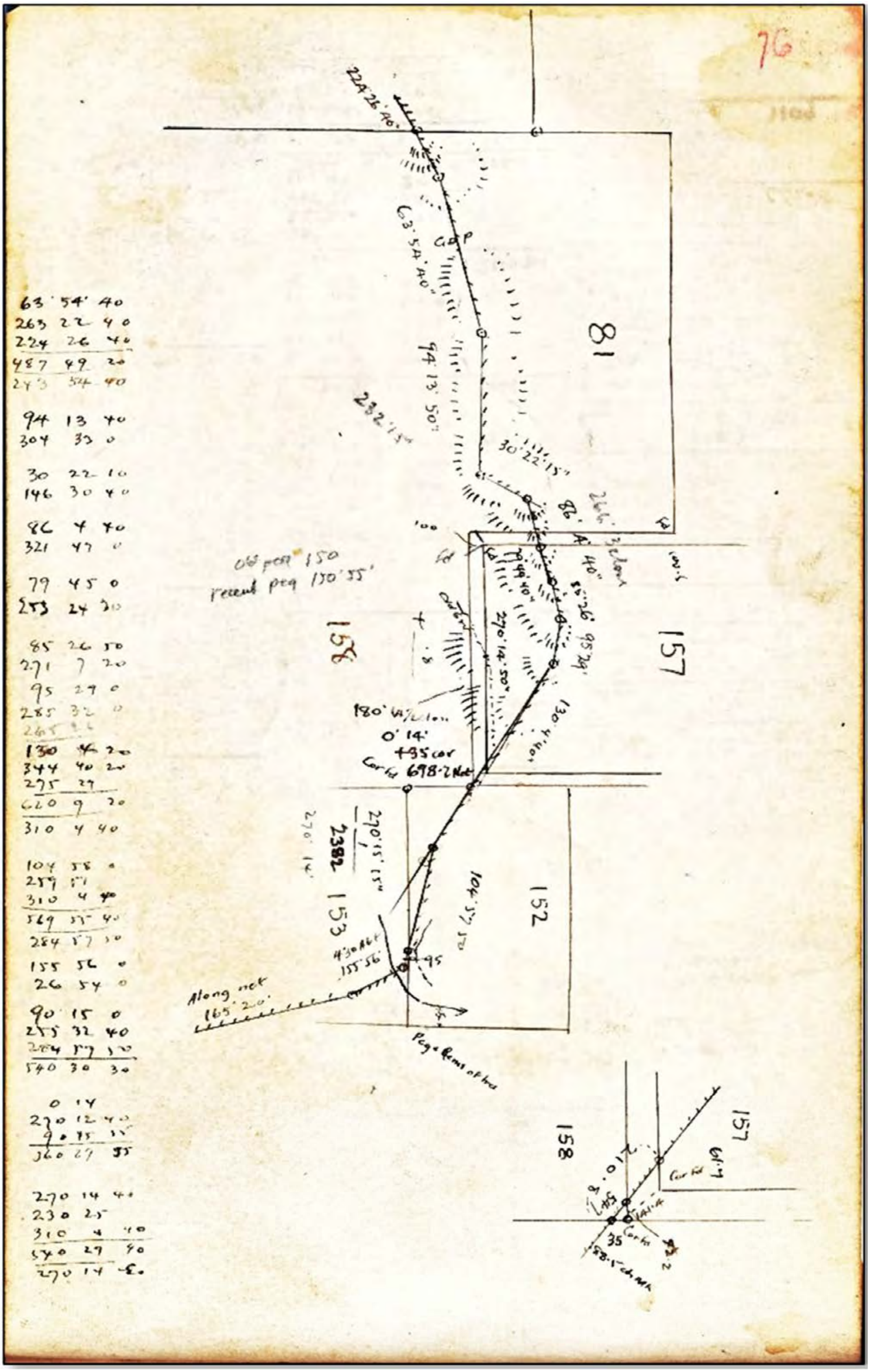


Figure 8: Plan of survey from the column field notes.

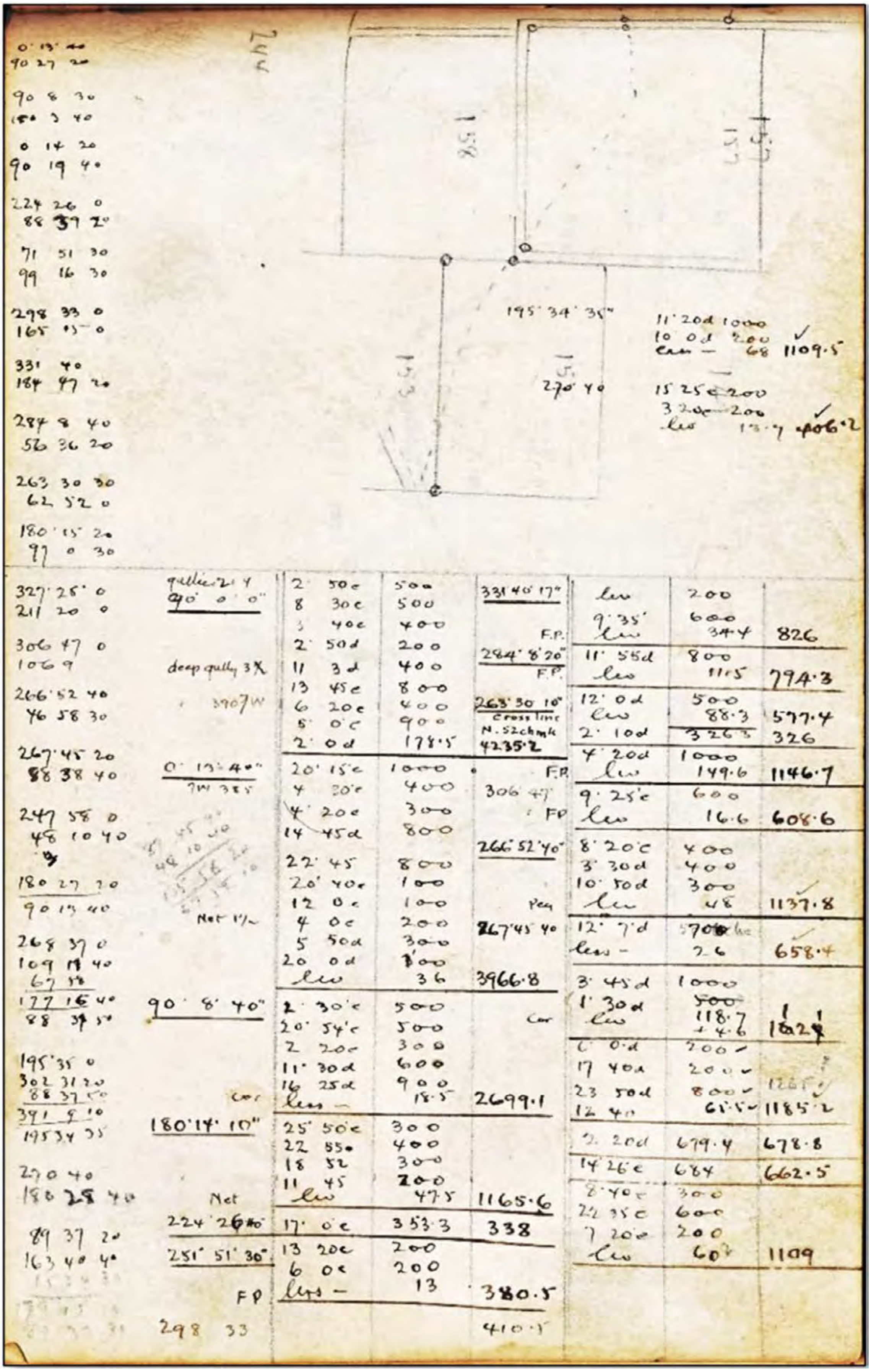


Figure 9: Plan of survey from the column field notes.

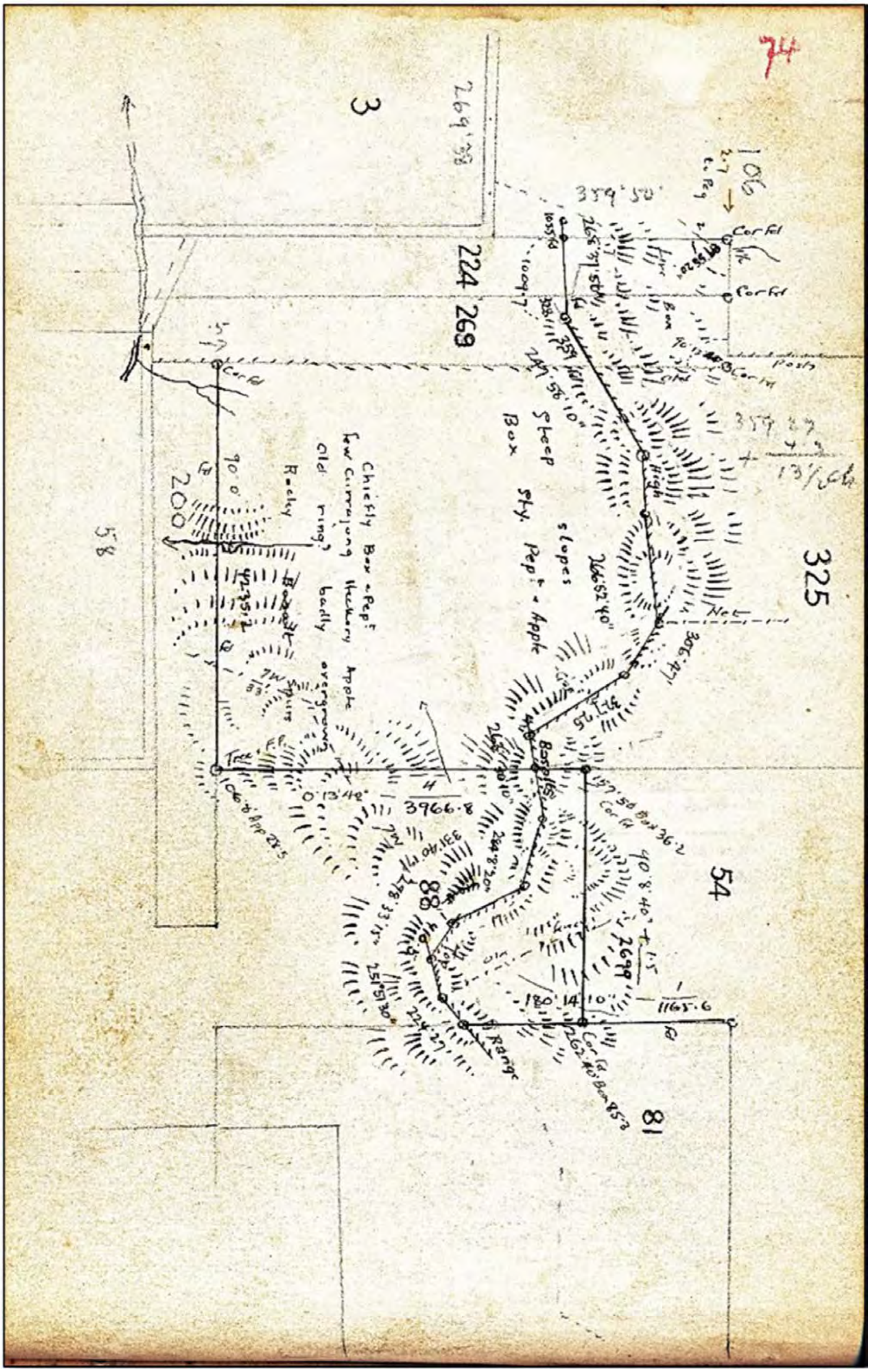


Figure 10: Plan of survey from the column field notes.

certain gorge in the parish of Colong, county of Westmoreland, through which the explorer passed, be named "Barrallier's Pass." Mr. Ashford thinks the suggestion a good one, and has given his approval that the name should appear on the official maps and plans.

Members will remember that Mr. Cambage gave a lantern lecture in 1910 on the above subject.

ASTRONOMICAL NOTES FOR MARCH, 1915.

Culminations.

NORTH OF ZENITH.

Star.	Mag.	Mean R.A.	Mean Dec.
		H. M. S.	° ′ ″
γ Geminorum (Alhena)	1·9	6 32 50	N. 16 28 26
ε Geminorum (Mebsuta)	3·2	6 38 44	,, 25 13 6
β Geminorum (Pollux)	1·2	7 40 9	,, 28 14 1
α Lyncis	3·4	9 15 56	,, 34 45 8
ε Leonis	3·1	9 41 5	,, 24 9 52
α Leonis (Regulus)	1·3	10 3 53	,, 12 22 50

CIRCUMPOLAR.

Star.	Mag.	Mean R.A.	Mean Dec.
(Upper.)		H. M. S.	° ′ ″
α Pictoris	3·3	6 47 20	S. 61 51 13
δ Argûs	2·0	8 42 23	,, 54 24 2
β Argûs	1·7	9 12 18	,, 69 22 14
(Lower.)			
λ Pavonis	4·4	18 44 22	,, 62 17 4
δ Pavonis	3·6	20 0 25	,, 66 23 52
α Toucani	2·9	22 12 41	,, 60 40 56

Elongations.

WESTERLY.

Star.	Mag.	Mean R.A.	Mean Dec.
		H. M. S.	° ′ ″
β Hydri	2·9	0 21 16	S. 77 43 51
α Eridani (Achernar)	0·5	1 34 33	,, 57 40 9
α Argûs (Canopus)	—1·0	6 22 5	,, 52 39 8

Figure 11: Astronomical notes from *The Surveyor*, 30 January 1915 (p. 20).

EASTERLY.

η Argûs	var	10 41 48	,,	59 14 26
α Crucis	1·0	12 21 54	,,	62 37 50
β Centauri	0·8	13 57 52	,,	59 57 53

Local Sidereal Time at Mean Noon, 10hrs. E. Long.

			HRS.	MIN.	SEC.
March	1	... ...	22	31	11·50
	5	... ...	22	46	57·72
	10	... ...	23	6	40·49
	15	... ...	23	26	23·25
	20	... ...	23	46	6·02
	25	... ...	0	5	48·79
	30	.. ...	0	25	31·56

G. L. WILKINS.

Correspondence.

TO THE EDITOR OF "THE SURVEYOR,"

Dear Sir,—

In reference to Mr. Frank Clarke's letter in your last number, the following may be of interest :—

The convergence of meridians between any two points is given approximately by the following formula (*vide* Mr. J. H. Cardew's Surveyor's Pocket Book).

$$\text{Convergence (in secs.)} = \text{Departure in arc (secs.)} \times \text{tan of mean latitude}$$

$$= \frac{\text{Departure (in chains)}}{1{\cdot}54 \text{ ch.}} \times \text{tan of mean latitude}$$

the arc referred to being the arc of a great circle of the earth, on which 1.54 chains is the length of 1 second.

Thence, in this case,

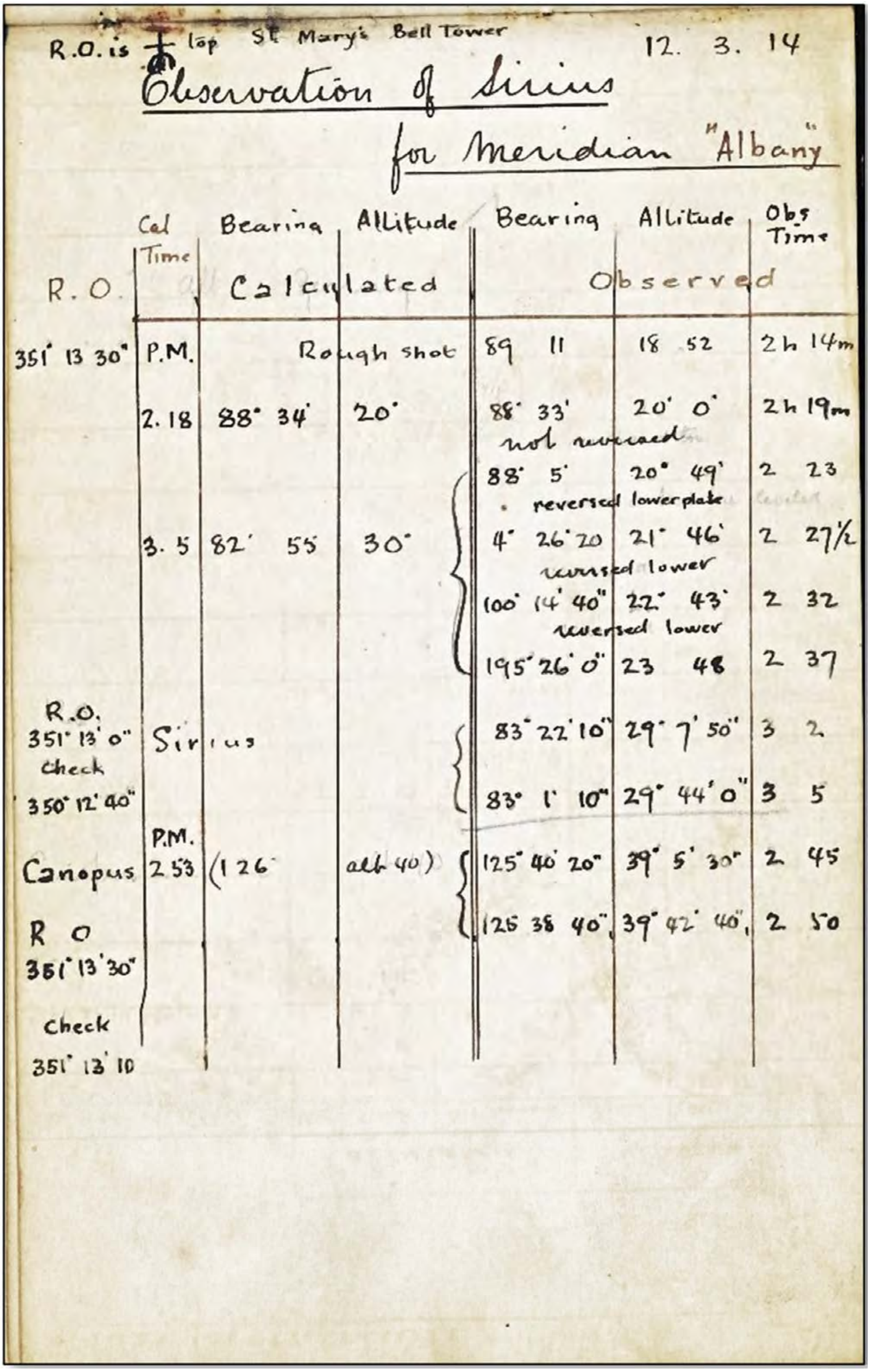
$$\text{Convergence (in secs.)} = \frac{912}{1{\cdot}54} \times \tan \frac{32^\circ\,23'\,04'' + 32^\circ\,20'\,09''}{2}$$

$$= \frac{912}{1{\cdot}54} \tan 32^\circ\,21'\,36''$$

$$= 6'\,15''$$

Since the departure from A to B has been Easterly the true bearing of the line AB (produced) at B will be less than that of the same line at A by 6′ 15.″ Thus all true bearings on the meridian of the Eastern point B should be less than the bearings of the same

Figure 12: Astronomical notes from *The Surveyor*, 30 January 1915 (p. 21).



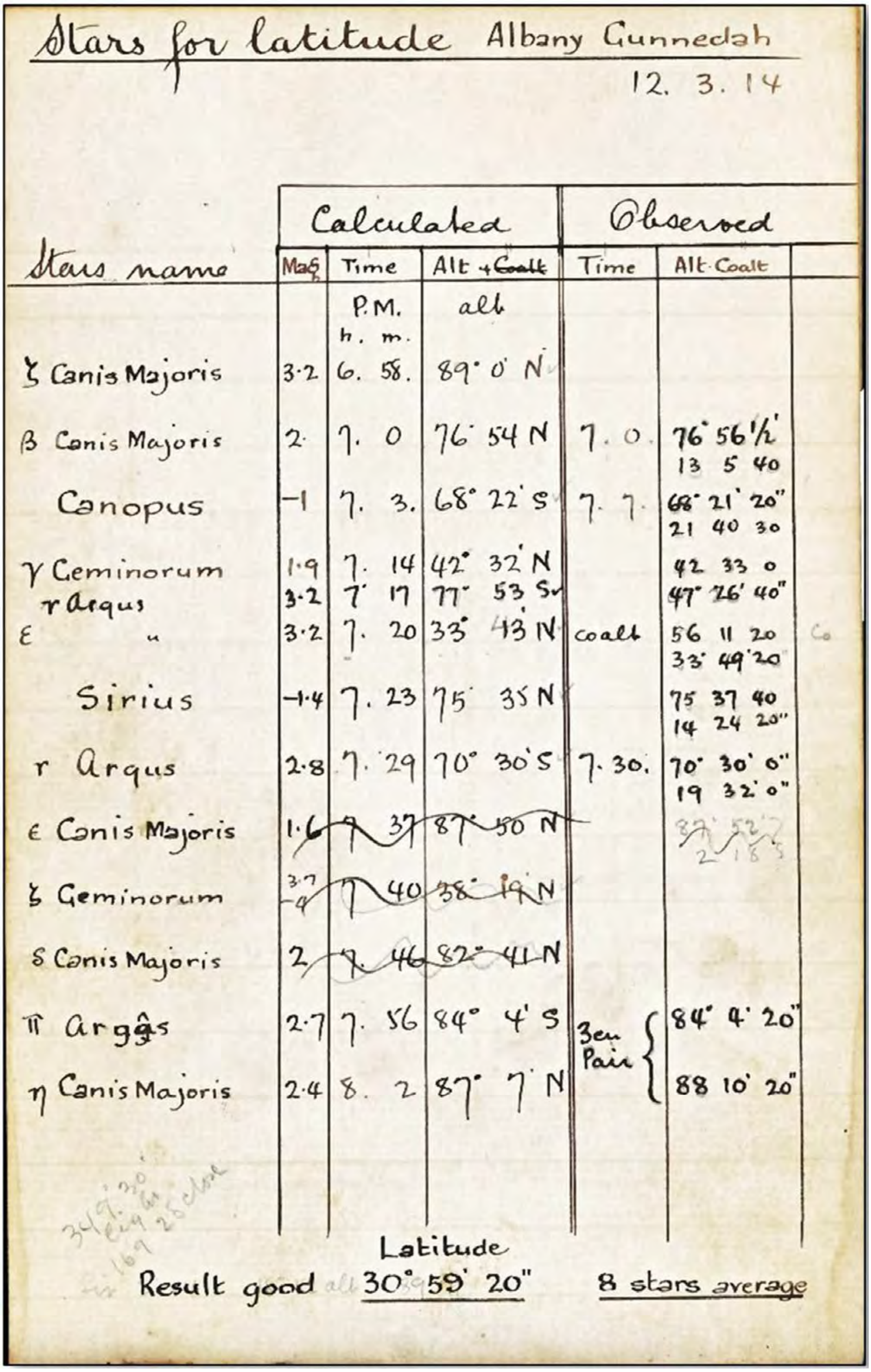
R.O. is ✝ top St Mary's Bell Tower 12. 3. 14

Observation of Sirius

for Meridian "Albany"

R.O.	Cal Time	Bearing	Allitude	Bearing	Allitude	Obs Time
		Calculated		Observed		
351° 13 30"	P.M.		Rough shot	89 11	18 52	2h 14m
	2.18	88° 34'	20°	88° 33'	20' 0'	2h 19m
				not reversed		
				88° 5'	20° 49'	2 23
				reversed lower plate		
	3. 5	82' 55	30°	4° 26' 20	21° 46'	2 27½
				reversed lower		
				100° 14' 40"	22° 43'	2 32
				reversed lower		
				195° 26' 0"	23 48	2 37
R.O. 351° 13' 0"	Sirius			83° 22' 10"	29° 7' 50"	3 2
Check 350° 12' 40"				83° 1' 10"	29° 44' 0"	3 5
Canopus	P.M. 2 53	(126	alt 40)	125° 40' 20"	39° 5' 30"	2 45
R O 351° 13' 30"				125 38 40"	39° 42' 40"	2 50
Check 351° 13' 10						

Figure 13: Observations of Sirius.



Stars for latitude Albany Gunnedah

12. 3. 14

Stars name	Calculated			Observed	
	Mag	Time	Alt + ~~Coalt~~	Time	Alt Coalt
		P.M. h. m.	alt		
ζ Canis Majoris	3.2	6. 58.	89° 0' N		
β Canis Majoris	2.	7. 0	76° 54 N	7. 0.	76° 56½' 13 5 40
Canopus	-1	7. 3.	68° 22' S	7. 7.	68° 21' 20" 21 40 30
γ Geminorum	1.9	7. 14	42° 32' N		42 33 0
r Argus	3.2	7 17	77° 53 S		47° 26' 40"
ε "	3.2	7. 20	33° 43 N	coalt	56 11 20 33° 49' 20
Sirius	-1.4	7. 23	75 35 N		75 37 40 14 24 20"
r Argus	2.8	7. 29	70° 30' S	7. 30.	70° 30' 0" 19 32' 0"
ε Canis Majoris	1.6	~~7 37~~	~~87 50 N~~		~~87 52~~ ~~2 1 8~~
ζ Geminorum	3.7-4	~~7 40~~	~~38 19 N~~		
δ Canis Majoris	2	~~7. 46~~	~~82 41 N~~		
π Argûs	2.7	7. 56	84° 4' S	Sen Pair	84° 4' 20"
η Canis Majoris	2.4	8. 2	87° 7' N		88 10' 20"

Latitude

Result good 30° 59' 20" 8 stars average

Figure 14: Stars for latitude.

5 CONCLUDING REMARKS

Many surveyors, particularly in regional areas, are required to redefine boundaries that have been measured with link chains and circumferentors (which only measure angles, not bearings). This requires a clear knowledge and understanding of the practice and use of these instruments. This paper has briefly outlined these methods, explained how to interpret the resulting survey plans and described the method of redefining these boundaries. It is hoped that this contribution will help surveyors make sense of historical survey information in the modern era of surveying.

REFERENCES

NGV (2022) Surveyors (1865), plate 17 from The Australian Sketchbook 1864, S.T. Gill, https://www.ngv.vic.gov.au/explore/collection/work/29440/ (accessed Mar 2023).

Determining the Future Demand, Supply and Skills Gap for Surveying and Geospatial Professionals: 2022-2032

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Association of Consulting Surveyors
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ABSTRACT

The Association of Consulting Surveyors National (CSN) has been keeping a watchful eye on the demand for surveyors across Australia since 2012, providing a future look over the next 10 years into the requirements for the profession. CSN commissioned BIS Oxford Economics to provide an updated workforce capability study utilising the 2021 census data and the most recent developments across educational completions and labour market indicators. Demand drivers for our profession include the property, construction and mining sector. Supply drivers include education enrolments and qualification completions (including registration and licensing), demographic ageing of the existing workforce and its impact on retirement within the surveying profession, and productivity growth driven by new technologies, practices and systems. Where measures of workforce demand exceed currently available supply, it is referred to as a workforce gap. The 2022 report highlights where and when workforce gaps are likely to be observed over the coming decade for each state and territory. Where gaps are unlikely to be filled by new supply at a national level from the education system, a capability deficit arises. This presentation highlights the key findings of the research and report, including (a) the current total workforce for surveying and geospatial professions is now 19,000 persons with 10,800 employed as surveyors, a 22% increase since 2017/18 although the number of licensed/registered surveyors decreased by 7.7% to just under 2,400, and (b) the increase nationally in infrastructure projects and a backlog in residential development will drive the demand for surveyors over the next two years, with a peak in demand in 2023/24 requiring 20,200 professionals. In the same year, the capability gap will reach 1,500 professionals as new supply from graduates falls short of the increased demand. This presentation also identifies the focus areas for the profession in the coming few years to ensure a sustainable and increased output from the workforce is achieved, particularly within New South Wales. In addition, two new aspects to the report feature in the presentation, i.e. the value surveying adds to the broader property and construction sector, and the impact of natural disasters on the workforce capability. The full report will be available at https://www.consultingsurveyors.com.au/our-industry/industry-research/.

KEYWORDS: *Demand for surveyors, education, skills, registration, value of surveying.*

Coastal Erosion: An "Elegantly Simple Solution" at Harrington

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ABSTRACT

An "elegantly simple solution" was how Engineer Bruce Collins described a proposal from Surveyor Grant Calvin to address the problems of siltation within the entrance of the Manning River at Harrington on the Mid North Coast of NSW. He provided full support for this economic and viable answer to these siltation problems. This paper first explores the background to the problem and its solution, providing historical and current maps of the area in explanation of the hydrological forces involved. A photographic record of the coastal erosion that appears to be caused by a shifting river entrance at Harrington is also presented. It then looks at the historic recovery of the beaches when the entrance stabilises in a location by the Harrington sea wall, which is the desired outcome of this solution for the river between Harrington and Manning Point and the beaches south to Old Bar. The ideas presented in this paper have the potential to dramatically reduce coastal erosion in at least one of the coastal erosion hot spots in New South Wales, at a fraction of the cost of other heavily engineered solutions.

KEYWORDS: *Harrington, Manning River, beach erosion.*

1 INTRODUCTION

The northern entrance of the Manning River at Harrington has always had shifting and siltation problems. After extensive investigations in the late 1880s by eminent British harbour designer Sir John Coode (Coode, 1889), a design was prepared, adopted and commenced for rock walls to facilitate safe shipping. The closing comments of Coode's report included a warning that the project should be completed in its entirety as designed: "It would certainly be preferable to defer action rather than embark on a project of insufficient scope or extent."

Unfortunately, over the course of time, the economic importance of a safe entrance to the Manning River has been reduced due to increase of rail and road infrastructure. Consequently, it was never completed. The long-term implications of not completing the project are currently showing with massive environmental degradation impacts of siltation, entrance mobility and devastating beach erosion.

A simple modification to the existing northern wall as proposed by this paper may reduce siltation, enhance natural scouring required to maintain a deep channel along the break wall and in turn dramatically reduce beach erosion evident along the adjoining beaches. These modifications, utilising the natural ebb and flow of the tides, are negligible in comparison to the long-term impacts of not doing anything. There are no perceivable negative effects. With the cost of perpetually studying the situation and never determining an ideal scenario, it is about time to try a tangible, simple proposal at a cost that is lower than some of the individual studies.

A 300 m shift in the beach alignment has occurred on the southern shore of the river entrance at the northern tip of Mitchells Island. This shift can be seen in the aerial photographic record around 1965-69 and 2011-22 and to a lesser extent around 1997. The beach to the south adjusts to keep in contact with this 300 m shift in the beach alignment. During the most recent event, the adjustment of the beach alignment and erosion of the foredunes has been photographed and forms part of this paper. The apparent cause of this change in the beach alignment is anthropogenic with a shoal of rocks in the beach being problematic.

Erosion along this beach has been subject to numerous studies (see section 9). To date none of these has made the connection between these seemingly innocuous rocks and the dramatic and devastating erosion that occurs on the adjoining beaches when the river interacts with these rocks (Figure 1). For comparison, if a similar 300 m shift in the beach alignment occurred at Collaroy, an erosion site of recent interest, the residents on The Avenue, located a couple of blocks west of Pittwater Road, would have ocean frontage (Figure 2).

Figure 1: Shoal of rocks on the beach that play their part in the occurring beach erosion.

Figure 2: Photomontage of the effect a 300 m shift would have at Collaroy Beach.

This paper explores the background to this problem and its solution, providing historical and current maps of the area in explanation of the hydrological forces involved. A photographic record of the coastal erosion that appears to be caused by a shifting river entrance at Harrington is also presented. It then investigates the historic recovery of the beaches when the entrance stabilises in a location by the Harrington sea wall, which is the desired outcome of this solution for the river between Harrington and Manning Point and the beaches south to Old Bar and Wallabi Point.

2 AN ELEGANTLY SIMPLE SOLUTION

"Time is an illusion – lunch time doubly so", a line from Douglas Adams' poorly named trilogy *The Hitchhiker's Guide to the Galaxy,* is an apt place to start. The idea behind this "elegantly simple solution" came along one lunch time, as they do. It was the start of a journey that led to historic engineering reports and government investigations, crossing paths with a wide variety of people, state bureaucracy and exalted engineers' reports that only a fertile mind like Adams might conjure up. This paper attempts to describe this journey.

At lunch time, survey field parties everywhere seek a comfortable high point from which to observe surroundings as the sandwiches or hot pies are consumed. At Harrington, the place to go for lunch is Pilot Hill overlooking the northern entrance of the Manning River. This location has always been a prominent place for surveyors. From this vantage point, on this particular lunch time in the 1990s, you could observe a jet of water spewing through the rock sea wall at the bottom of an outgoing tide. It looked like this jet of water was literally bending the flow of the ebb tide and pushing it away from the wall. On this day, it looked like this disruption to the river's tidal flow had caused the river to change direction and flow to the sea well away from the rock wall that had been built to guide its flow.

On this particular lunch time, the surveyor chainman banter included thoughts like "Could the energy down there be redirected to actually stabilise the river entrance up against the rock break wall?", "Would that maintain a usable entrance into and out of the river?" and "Could the changes observed in the river entrance that day be prevented by simply redirecting the flows we were observing?" It was a thought bubble of this ilk that led to the "elegantly simple solution" presented in this paper.

That thought bubble may have burst right then and there and died as most lunch time discussions do, had it not been shared with local Engineer Bruce Collins back at the office that afternoon. Bruce, the Collins in Collins Walshe & Fitzsimmons (CW&F), was the engineer in the consulting surveying and engineering firm in Taree. He was enamoured with the ideas and encouraged progressing it into a working concept. With the firm's backing, local photographer Karl Bayer provided a quality electronic image and Peter Calabria, from Sunne Printing, generated a photomontage of the jet of water and the concepts (Figure 5). A colour poster was produced (Figure 3) and sent out with letters of support from Bruce (Figure 4) to council, politicians, the Public Works Department (PWD) and the like. Bruce and his father-in-law Jack Dunn took a stand at the local Envirofair, displayed the poster and handed out flyers to attendees.

To put this into perspective, in the late 1990s electronic manipulation of imagery was not widely available. Sunne Printing's computing systems, though old hat now, provided computing power beyond anything else available in town. Both Peter and Karl, upon hearing about the concepts we were trying to portray, provided their imagery, time and expertise gratis to the cause.

What caused this jet of water through the rock wall? To answer this question, we need to gather a bit of background information. Note that the jet of water going out also goes inside the wall with the flood tide. A plume of sand locates the 'gantry' or hole in the wall. This plume of sand, visible in aerial images, will assist the reader in locating the 'gantry' in the images.

Figure 3: Original promotional poster from Collins Walshe & Fitzsimmons (1999).

COLLINS, WALSHE & FITZSIMMONS
PTY. LTD. — A.C.N. 001 955 620
Consulting Engineers and Surveyors

I E Aust

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15 June 1999

Stebercraft
Elizabeth Avenue
TAREE NSW 2430

ATTENTION: ALLAN STEBER

Dear Sir

RE: THE MANNING UNPLUGGED

Grant Calvin is a surveyor with Collins Walshe & Fitzsimmons Pty Ltd has developed an explanation for the current problems with the siltation of the Manning River entrance at Harrington and has developed a solution to this problem. His solution is elegantly simple and utilises existing structures without major works. The limited work involved in implementing Grant's solution means that the costs will be limited.

Grant is seeking support for his solution as an economic and viable answer to the siltation problems at the river entrance. I have assessed his proposal and he has my full support.

Please contact myself or Grant if you have any questions in relation to this matter.

Yours faithfully
COLLINS WALSHE & FITZSIMMONS PTY LTD

BRUCE COLLINS MIEAust CPEng

Figure 4: Engineer's letter of support for an "elegantly simple" solution.

Figure 5: Harrington circa 1998, courtesy of Karl Bayer and photoshopped by Peter Calabria.

3 HISTORICAL BACKGROUND

In the 1800s, the Manning was a rural settlement that supplied raw materials consumed by the growing colonial cities of Newcastle and Sydney to the south. Trade with these major cities was by coastal ships that plied up and down the coastal rivers. Harrington was where these ships ventured into the sea from the Manning River. Navigation of "the bar" was fraught with danger and ships were often stuck and lost crossing into and out of the river system. The information sign atop Pilot (or Flagstaff) Hill tells us that over 50 ships were known to have foundered on the Manning bar between 1824 and 1941. To aid safe navigation of the bar, a marine pilot station was established in 1856 (Figure 6). The pilot boat was a 16-foot rowing skiff manned by a boat crew of 4 to 6 boatmen. Some 12 pilots served at Harrington continually from 1856 right through to 1961.

Figure 6: Pilot's house, boatman's cottages and the signal shed and flagstaff atop Pilot Hill, ca. 1900 (https://www.flickr.com/photos/glmrsnsw/24239664794/).

Not surprisingly, the pilot lived on Pilot Hill. The actual pilot's house is long gone but the flagstaff that communicated with ships awaiting entrance to the river still stands on the brow of the hill. In preparation, the pilot and his crew would row around and depth-sound the shoals and channels of the entrance. They would use this information to mark the best passage to take from the ocean into the river.

Approaching ships were observed from this prominent hill, signals sent to and fro using the flagstaff. The pilot would take to the pilot boat, row out to the ship and pilot her through the shoals and channels of the bar they had marked. The changeable entrance configuration meant sounding and marking the channels was a constant and ongoing operation for the pilot and his boatmen. Once over the bar, ships would go upriver to carry out their enterprises at the various river towns and villages.

Figure 7 shows an old parish map with Pilot Hill (indicated by the arrow) together with trigonometric station 464 marked (now TS2417 HARRINGTON) and the latitude and longitude of the Harrington Astronomical Station (31°52’26” S and 152°41’37” E) notated on the sandbanks in the river. The beginnings of the training wall can be seen at the base of Pilot Hill.

Figure 7: Parish map 1897, County of Macquarie, Parish of Harrington, edition 3 (LRS, 2023).

In the 1800s, coastal steamers and river traffic were the life blood of the many small communities that formed along the rivers of the north coast of New South Wales. The bar at the entrance to these rivers was a major impediment to this river trade. The importance of this trade was described in the Parliamentary Standing Committee on Public Works report in relation to the Harrington entrance and the Manning River. In 1909, exports included butter 2,228,571 lb, maize 300,000 bushels, timber 6,750,000 lineal feet with 1,825 passengers departing. Imports consisted of 5,600 tons of general merchandise. “The steamships trading to the port were those of the North Coast Steam Navigation company, Allan Taylor, Langley Brothers, Dick and Company (Newcastle) and Whatmore and Company. These [ships] paid 335 visits during the year ending 31 December 1909” (PWD, 1910).

The report went on to say the bar at Harrington “is considered one of the most, if not the most, dangerous bar on the colony, as shown by the number of wrecks and loss of life upon it.” The maps shown in Figures 8-10 were prepared in order to assess the changing nature of the bar and the potential for installing sea walls to provide a safer entrance into the river.

“Crossing the bar” when shipping perishable goods or livestock was risky. One report given to the Standing Committee (clause 1106) notes a total of 86 days of delay for 6 different steam ships due to the conditions of the bar in 1909. Ships were recorded as “bar-bound” unable to cross into the Manning River, with delayed departure from Sydney owing to bad bar conditions or aground. Delays in shipping could ruin perishable goods, causing financial loss for farmers.

In 1881, the Assistant Engineer for the Harbours and Rivers Department, Cecil West (C.W.) Darley, visited the site: "I proceeded to the Manning Heads and carefully examined the Entrance with the view of suggesting means of improving the navigation." He went on to say: "The Department being in possession of recent and accurate detailed surveys [Figures 8 & 9], little more than mere inspection of the locality was necessary on my part." He suggested some dredging and provided some ideas to building a sea wall, including where the source of rock may come from at Crowdy Head (Darley, 1881).

His commentary was prescient on the outcome currently in place: "To maintain the channel in its present position would be most desirable, but it could only be effected by the construction of a costly breakwater extending out from the 'Painted Rocks' [at the base of Pilot Hill] a distance of about 2,500 feet [760 m], in an east by south direction. In the event of a break wall being run out, it will become necessary to protect the foreshore westward from the 'Painted Rocks' by a training dyke about three quarters of a mile in length [1,210 m], otherwise the wash which will be thrown in along the breakwater will encroach upon the beach and cause the channel to shoal up or take an irregular course."

The 'Painted Rocks' were on the corner of the river at the base of Pilot Hill. Some pundits have said they were so called because the narrow shipping channel passed so close to the shore that vessels were said to scrape the paint off their sides (McNeil, 2011a). It is considered more likely that the prominent rocks adjacent to the deep channel were where birds roost, consistently watching for prey or drying their wings. The 'Painted Rocks' at this corner in the shoreline were probably painted white with guano and were a clear marker as reference to these 'Painted Rocks' is common in the texts.

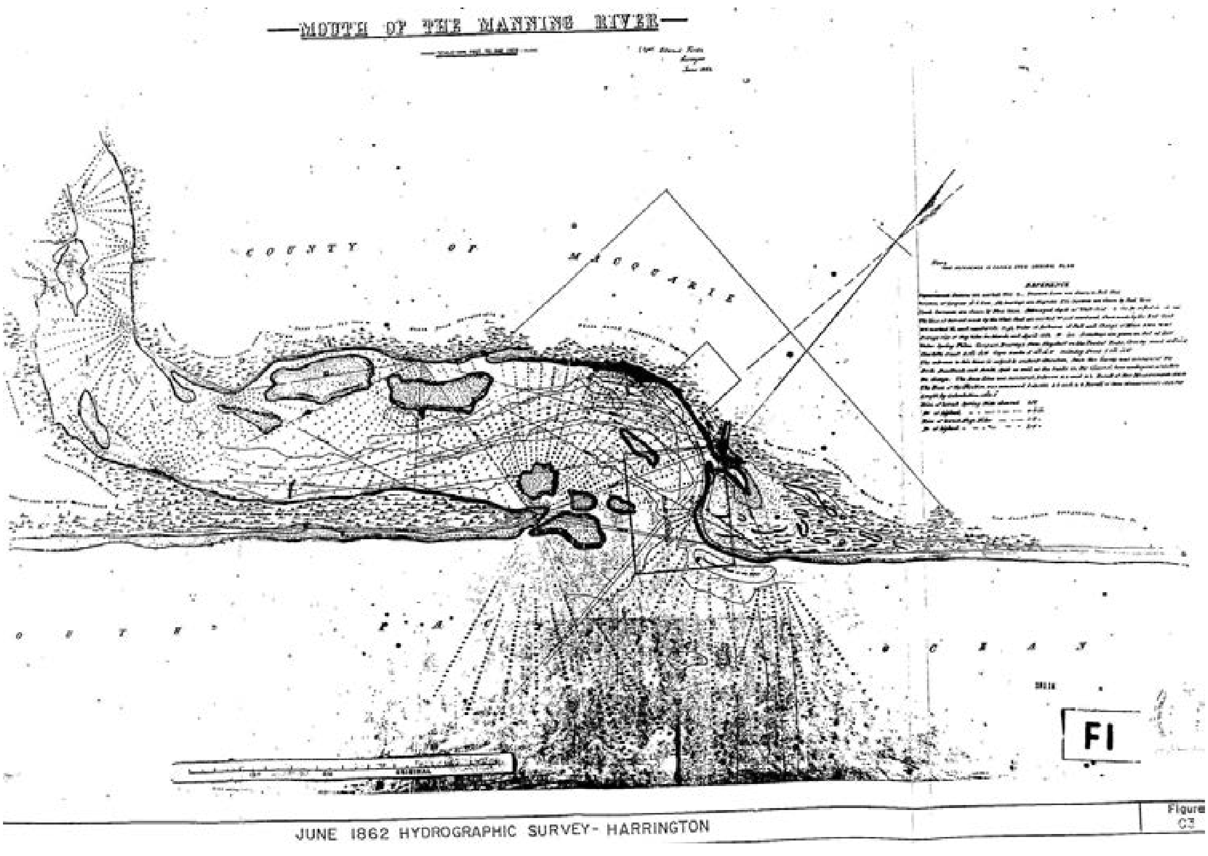

Figure 8: Mr Forde's survey, 1862.

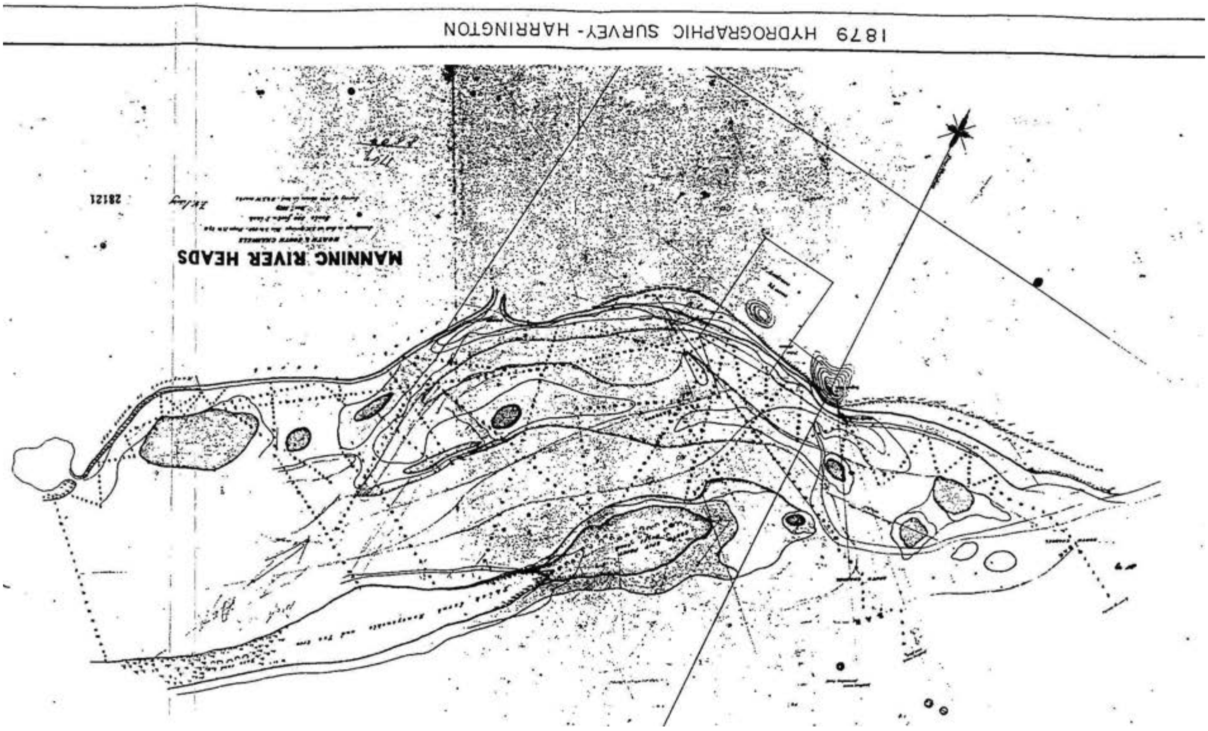

Figure 9: Mr Sydney's survey, 1879 (deliberately reversed to keep orientation of harbour similar).

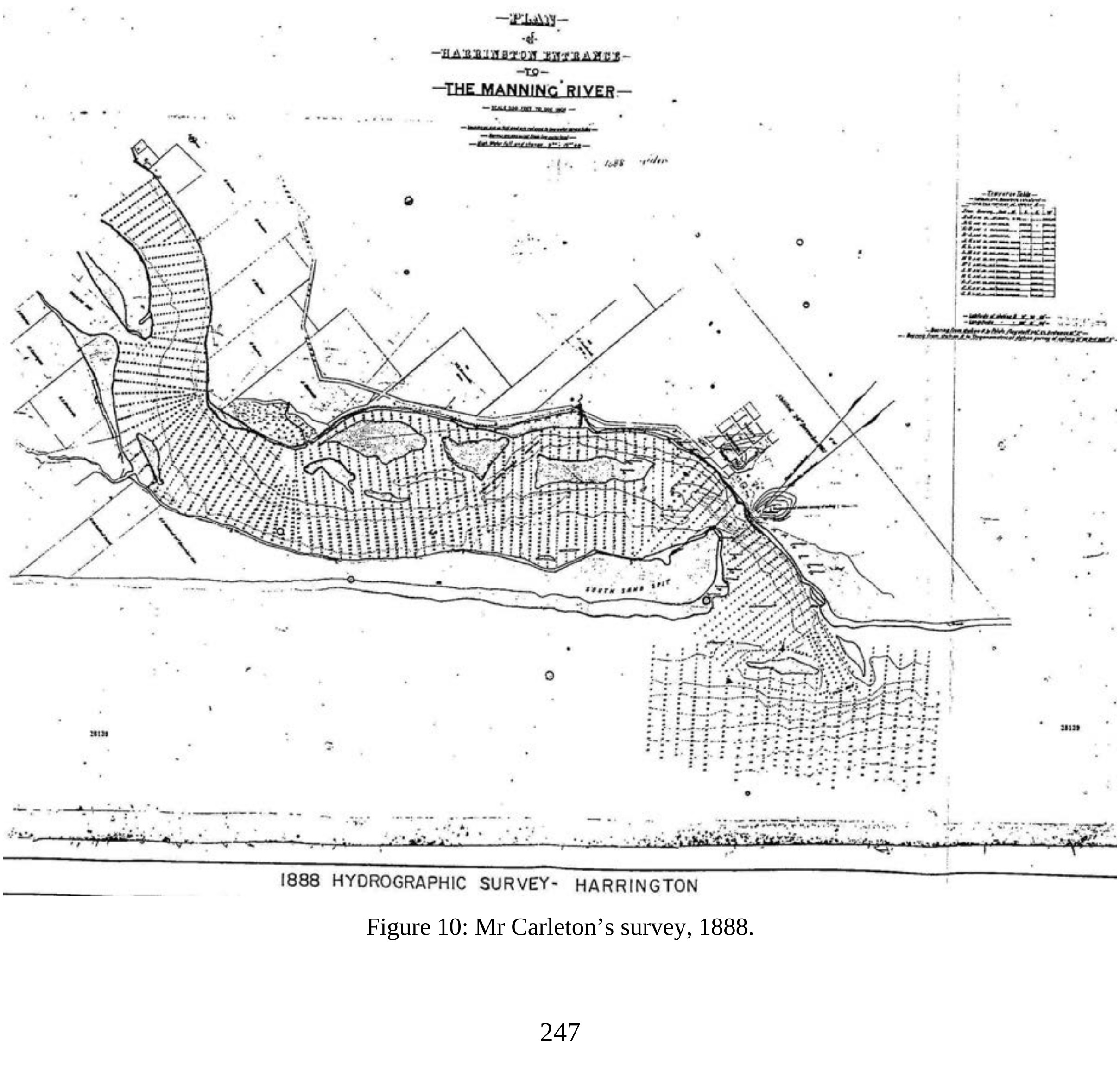

Figure 10: Mr Carleton's survey, 1888.

In 1885, the prominent harbour engineer John Coode visited Australia and was employed by the government to provide information on a number of harbour works. He met with the master of the steamer Rosedale, Captain Martin Prendergast, who regularly traded on the Manning River, making several trips per month and Mr John Muir, the pilot of 10 years on the Manning. Coode gave detailed instructions for the compilation of information to assess the situation. This information was provided by Henry Richard Carleton, Supervising Engineer with the Harbours and Rivers Navigation Department, and provided as an appendix to Coode's report (Coode, 1889). His report included commentary on the river system and its tributaries and principal towns. There were also cross sections and soundings providing waterway areas, catchment areas, rainfall and flood measurements, wind records and borings taken on the sand spits in the entrance checking for possible reefs.

Upon receipt of Carleton's information, Coode, now back in England, compiled a report and plan (Figure 11). Part of the information compiled by Carleton to Coode included the catchment area of the Manning, no mean feat in 1889, given the ruggedness of the Barrington Tops that form part of the catchment boundary. His calculations showed a catchment area of 3,170 square miles (8,210 km²) and broke that down into the sub-catchments of the tributaries (Barrington & Barnard, Gloucester & Avon, and Dawson & Lansdowne). For comparison, recent flood studies provided 8,160 km² as the Manning River catchment area. This is an indication of the quality of the information provided to Coode for his assessment.

Mr Carleton's 1888 survey (see Figure 10) was used in the production of the plan by harbour engineer and designer Sir John Coode. In summary, Coode's plan was for:

- Southern breakwater: 4,000 feet (1,220 m).
- Barrier bank to south spit: 6,700 feet (2,040 m).
- North training bank: 2,300 feet (700 m).
- Northern breakwater: 2,200 feet (670 m).

He estimated an expenditure of £194,000. Coode's plan (see Figure 11) included a low training bank extending seaward of the 'Painted Rocks' to be only 2 feet above low water. This bank would guide the flow of the tides yet allow wave action to flow over it. Behind this training wall, between the training wall and the proposed northern breakwater, is a wave trap or stilling beach. Waves propagate in the entrance break over the training wall and dissipate their energy on the small beach. This would ameliorate the wave action for which Darley suggested a 1,210 m long training dyke is required as protection.

The barrier bank on the south spit is similar to the dyke suggested by Darley in that it prevents erosion of the sand spit from the actions of the river flows. Coode's design, however, continues the south barrier bank to become the southern breakwater. Thin red lines depict the training wall and barrier bank, while thick red lines show the breakwater or sea walls. Coode proposed that the opening between the south and north walls be 800 feet (250 m) wide. This width "will be sufficient for the discharge of flood waters without creating a gorge." Carleton's cross sections and flood flow measurements were used to calculate flows and provide these critical design criteria.

The closing comment of his report was prescient: "The expenditure I have named may be considered too great to be incurred under present conditions. Should this be the case, it would certainly be preferable to defer action rather than to embark on a project of insufficient scope and extent. Certainly, if any action is to be taken, it should be on the line referred to herein and shown on the accompanying drawings."

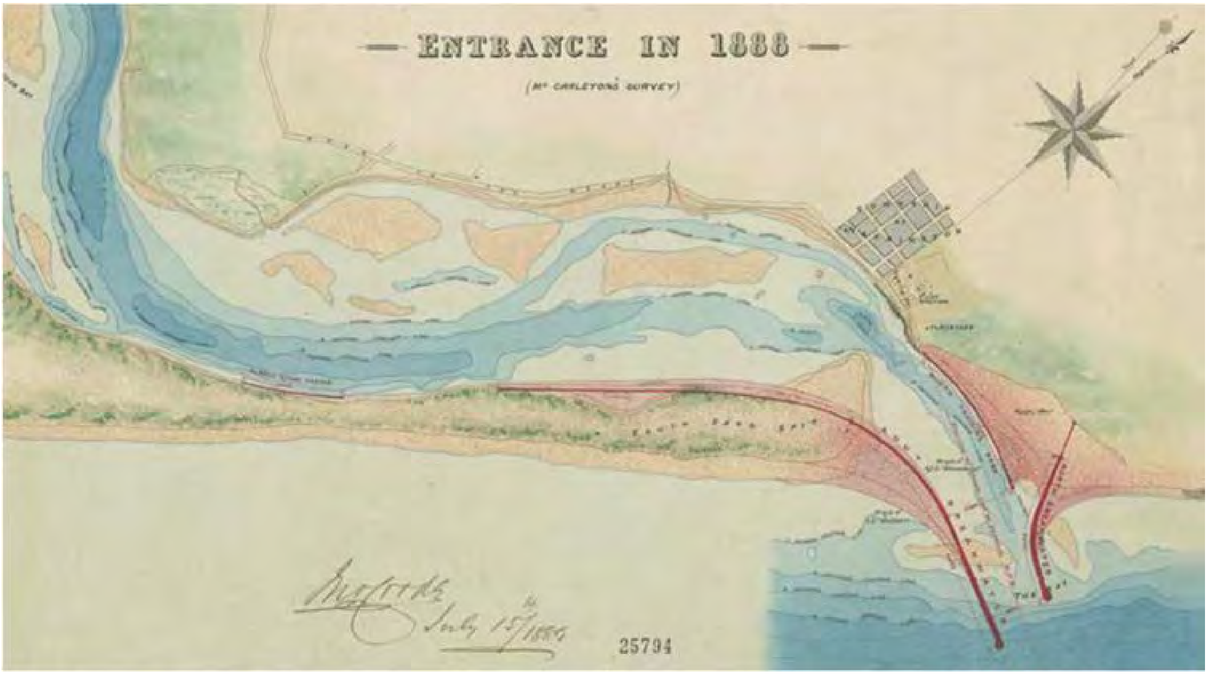

Figure 11: Entrance in 1888 and Coode's proposed rock walls, shown in red (DPI, 2018).

One might detect a certain amount of colonial engineers' one-upmanship here. The local engineer Darley, Engineer in the Chief Harbours and Rivers Navigation Branch of the Public Works Department from 1889, had planned for a single sea wall (760 m long) on the northern side of the river starting from the 'Painted Rocks' (at the base of Pilot Hill) and heading southeast, a river wall (1,210 m long) upstream of the 'Painted Rocks' and also a dyke of stone (2,400 m long) protecting the southern bank of the river upstream of the entrance (Darley, 1881).

The plan of English engineer Coode (see Figure 11 and Coode, 1889) showed rock walls only east of the 'Painted Rocks' (nothing upstream) and a southern wall extending from the sand spit to the south and extending to a point just beyond the extent of the northern wall. Coode's commentary was that the southern wall should be completed first or at least in conjunction with other works to afford protection of shipping from the prevailing southerly winds, wave action and incursion of sand into the entrance of the river.

Figure 12 shows the outcome of the construction as it stands today (the north spur was removed in the 1980s). Despite orders being issued by two separate Parliamentary Standing Committees on Public Works in 1898 and 1910 (PWD, 1910), recommending that Coode's plan be endorsed and constructed without delay, the current status of the entrance at Harrington is testament to whose plan has ultimately been followed by Public Works. There is no stilling beach.

Instead of Darley's suggested 760 m long north breakwater, it is 1,150 m long. The inner north training wall is 1,210 m long in Darley's report but ended up 2,900 m long. The north training wall and spur walls do not exist on Coode's plan. The important barrier bank to the south spit remains incomplete. The southern breakwater, an extension of the barrier bank shown in Figure 11 does not exist (marked as not built in Figure 12). It was Coode's plan that was publicised to the locals as the plan for the works and endorsed by the Parliamentary Standing Committee to be progressed, twice! Coode Street in Harrington has been named in his honour.

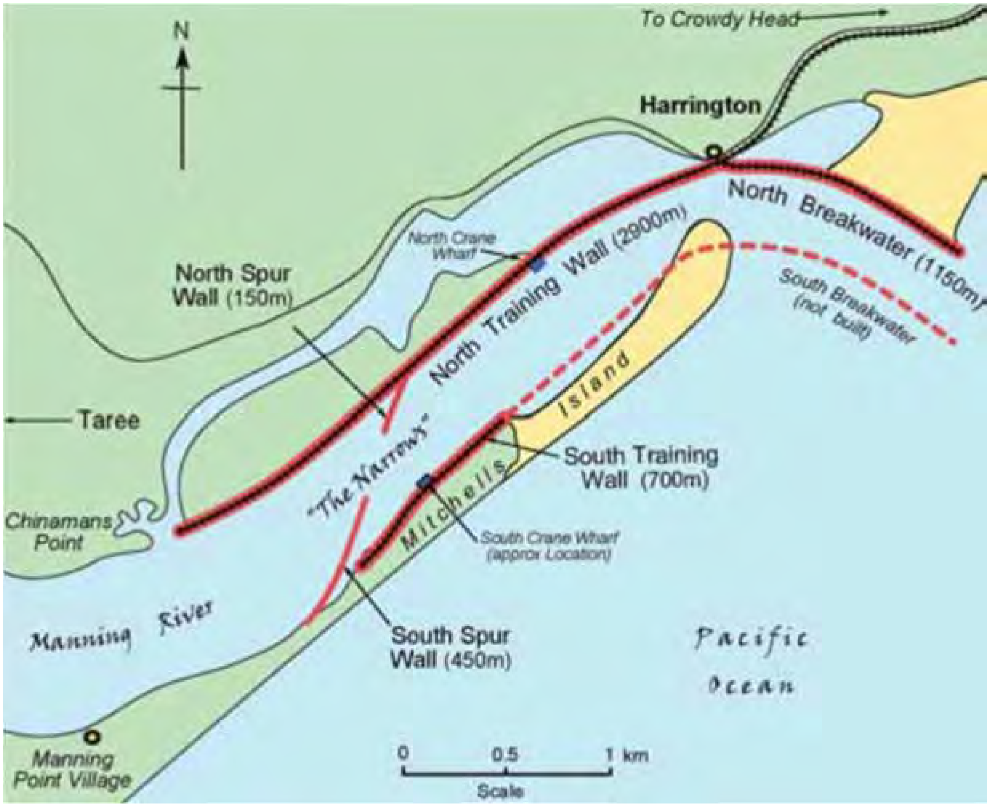

Figure 12: Rock walls today (McNeil, 2011a).

Importantly, the 2,900 m long north training wall was not part of Coode's plan. The south training wall (700 m long) in Figure 12, was in Darley's report meant to be a mile and a half long (2,400 m). In Coode's plan, the barrier bank to the south spit was designed to be 2,040 m long. The conclusion of Coode's 1889 report still rings true today, 134 years later. In today's parlance, if you cannot afford to do all the plan, then do not start. The communities of Harrington and the Manning Valley have been suffering the consequences of not following the closing comments of his report for more than 100 years now. One can only hope that this may be remedied in the near future.

One can imagine how the residents of Harrington felt as they watched the north training wall progress across the front of their town:

- Access to the sea for the local fishing fleet was getting cut off.
- The boarding and drinking establishments that had grown as part of this harbour port were literally getting cut off from their clientele.
- Local tourism was affected as it became more and more difficult to access the town for river traffic, which was still the primary conveyance around the area.
- For the pilot and his boatmen, the row or pull from their boat house out into the entrance, where they worked, increased every day.

A wharf was built on the outer side of the north training wall that was used to tranship passengers and freight onto more shallow draught vessels to continue journeys upriver when the lager ocean-going vessels found they could not enter the river. As early as 1898, the Manning River Times reported passengers for Harrington faced "a long and rough walk along the wall, and when the trucks are working it is not altogether safe." This wharf, known as the crane wharf, can be seen on the outer side of the wall in Figure 13.

Figure 13: Northern training wall extending upriver, ca. 1901 (Manning District Historical Society collection).

We know the boatmen were still rowing about, even though the steam tug John Gollan in Figure 13 was working the river. On 18 December 1901, a serious accident at Crowdy quarry was reported: "Mr George Henley, aged 28 years, was engaged with some other men yesterday (Tuesday) morning pulling stone from the face of the Crowdy Head quarry, when a large stone fell and struck him on the hip. He was brought to Harrington in the train, and was pulled up to Taree in the pilot boat – the John Gollan being engaged that morning – and was admitted to the Hospital about 2pm, where he was attended to by Dr Gormley" (McNeil, 2011a). A row of 27 km with a badly injured man in their 16-foot skiff indicates the strength of the pilot's boatmen, not to mention the return journey probably after some refreshing ales. One can only feel for the suffering of poor Mr Henley with a smashed hip. Row boats do not exactly run smoothly. Every catch of the oars comes with a jerk of the boat. His 27 km pull to the hospital would not have been a comfortable journey.

Imagine you are one of the boatmen who rows the pilot around the entrance to sound and mark the shoals. Your skiff is stored near the bottom right of Figure 13. Your daily row is extended with every rock that progresses the training wall upstream.

4 THE GANTRY

Some pundits say the 'gantry' was installed to provide for tidal flushing of the impoundment behind the wall that was cutting the town off from the river and the sea. However, local legend says it was a delegation of the pilot's boatmen that resulted in the gantry being installed. One might imagine that the engineer in charge of building the rock wall may well have been 'persuaded' that it would be in his interests to help out the boatmen with their daily grind by a forthright delegation of these strong rowers. Whatever the reason, some 430 m from the corner where the pilot's skiff was stored, a small opening was left in the rock wall with originally a timber bridge spanning the gap. The gap was supposed to give boat access to the local seafarers and fishermen from their town out into the river entrance and the sea.

The jet of water spewing through the rock sea wall we observed from Pilot Hill that particular lunch time was coming through this hole in the wall. Nearly a half a kilometre from the corner below us on Pilot Hill, this jet of water looked to be literally bending the river. Locally known as the gantry, the timber bridge has been replaced and updated in the intervening years. It still is not really suitable for boat traffic (Figure 14).

Figure 14: Gantry bridge, spanning a 13.5 m gap in the rock sea wall.

Flow, measured in this waterway, exceeds velocities of 2.2 m/s. On the ebb tide, the river drops below the level of the water behind the wall, and a drop of up to 0.5 m can be seen through this gap (Hawkins, 2007). The volumes of water that may be expected are actually easy to calculate, far easier than performing catchment calculations to work out flows in the traditional manner (e.g. CIA). Put simply, it is the area of the waterway behind the wall multiplied by the tidal height. The waterway area behind the wall, known locally as the back channel, is 58.088 ha. That is, a 1 m tide means that there will be a volume interchange of about 580,880 m^3. During spring tides, the volume of water interchanged may be closer to a million cubic metres (1,000,000 m^3).

It is these flows that the “elegantly simple solution” would utilise to stabilise the river channel up against the rock wall. When fishing in the upstream end of the back channel, the ebb tides seem to continue to flow into the channel from the upstream end for the entire cycle. This indicates that the flow volumes above may be conservative.

5 REDIRECTING THE GANTRY FLOWS

The idea is to close the current gantry, or potentially pipe it effectively, and create a similar opening at the inner corner some 400 m closer to the entrance, redirecting the tidal flows of the back channel along the face of the outer break wall. In this way, the forces that currently disrupt the tidal flow at the bottom of the tide will act as a giant venturi, literally dragging the river’s flow at the bottom of the tide toward the entrance. The venturi acting on the river’s tidal flow in this manner will have a multiplying effect on the flow volumes coming out of the back channel. It was suggested that the natural tidal flows, in the range of half a million to a million cubic metres of water, at every ebb tide will stabilise the river flows against the rock wall.

The rock walls that would be adjusted to achieve the redirection shown in Figures 15 & 16 can actually be seen in Figure 13. The sections of wall that would be adjusted are located between the camera position and the ship Electra and the tugboat John Gollan visible in the photograph. When drawn on the original 1998 imagery by Karl Bayer, the logic becomes clear (Figure 17).

Figure 15: Concept sketch of the water forces at play.

Figure 16: Concept sketch of how the water may be redirected.

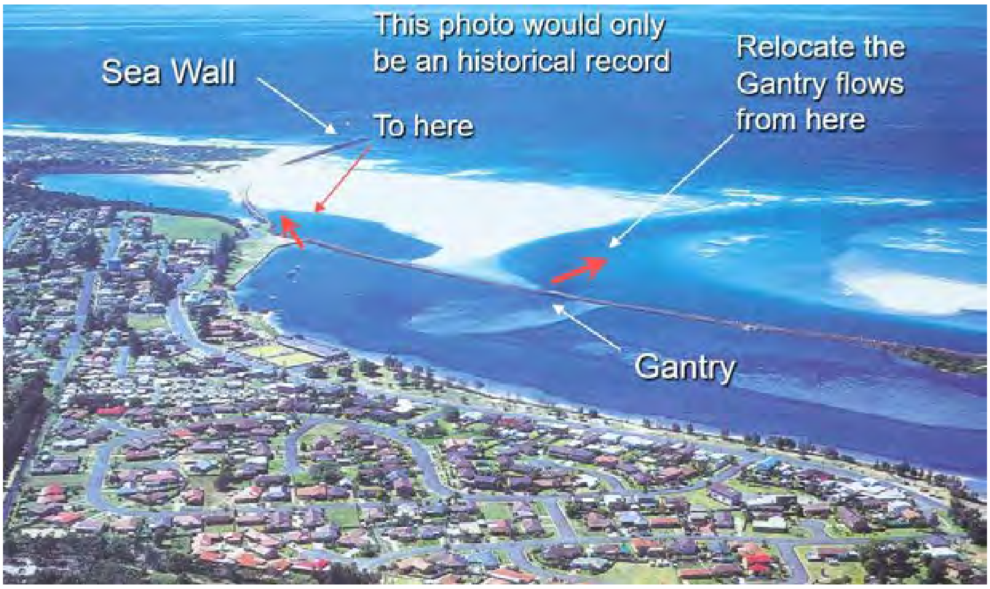

Figure 17: Concept of how the water may be redirected, drawn on the original 1998 imagery by Karl Bayer.

The apparent influence of the gantry on the river channel seems clear. What is there, but is not obvious in Figure 17, is the small channel that continues to flow along the face of the sea wall between the lagoon behind the green brow of Pilot Hill, all the way back to the river opposite the gantry. It seems that the tidal flux from the lagoon maintains this flow, even though the beach infills along and over most of the outer wall. In Figure 17, it can be seen that the water area, and thus tidal flow, of the back channel is vastly greater than this lagoon. It is believed that tidal flows from the back channel, jetting along the outer wall, will similarly maintain an open channel along the outer wall to the sea.

Figure 18 visualises the three components of the original concepts. In addition to relocating the gantry flows into the corner, the original concepts suggested that the existing hole at the gantry location may be piped, with the pipe laid in such a way that flow jetted into the sand on the outer side of the wall creates a scour hole just downstream. It was surmised that the tidal flows from the river would join these scour holes into a deep channel adjacent to the wall. This was described on the original poster developed by CW&F (see Figure 3).

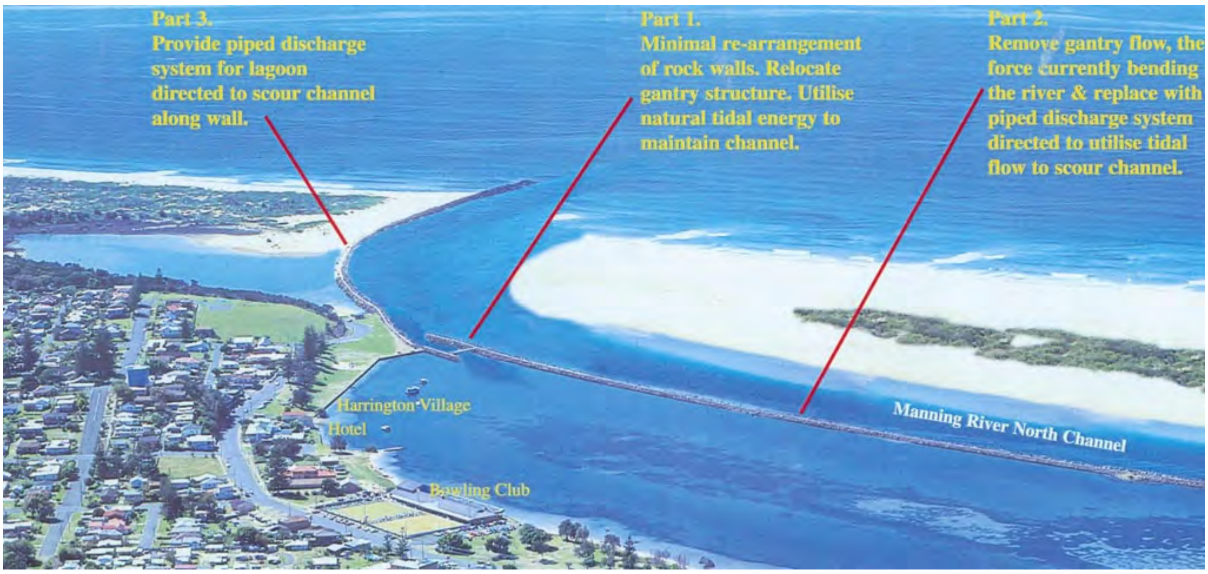

Figure 18: Photoshopped image illustrating the three components of the original concepts.

The proposed pipe system(s), which could be implemented at the gantry, are outlined in Figure 19. In combination, Figures 15-19 show that the scale of these proposed works is minuscule in comparison to the overall scale of the rock walls at Harrington – truly an "elegantly simple solution".

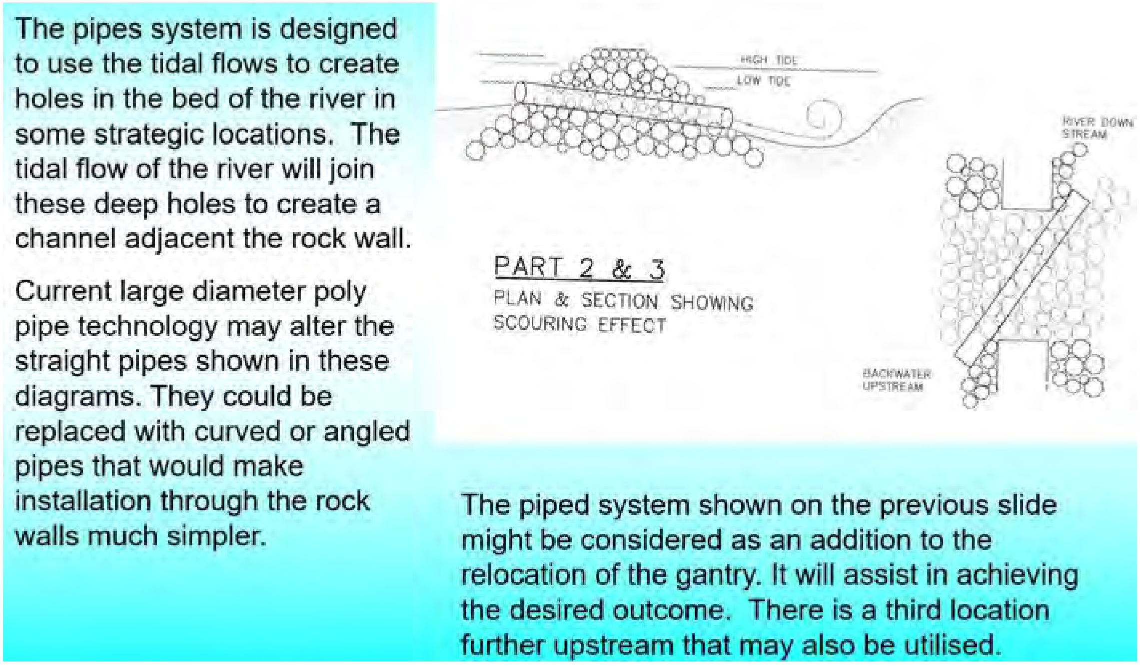

Figure 19: Proposed pipe system(s), which could be implemented at the gantry.

6 A QUESTION OF COST

A consulting surveying and engineering firm in Taree just does not deal with construction of sea walls, so understanding the costs involved in a project as proposed with these concepts was beyond our expertise. Therefore, a local contractor, Ron Mills of Mills Earthmoving who was and still is involved in repair works on the Harrington sea walls, was consulted. When asked about how we might go about costing these works, he suggested that it may be considerably less than $500,000.

The Manager of Minor Ports at the former Department of Lands heard of the concepts through the representations made of our local politicians and asked us to explain why we considered this project worthy of his attention:

- The jet of water coming out of the gantry appears to be disrupting the flow of the river in the entrance particularly at the bottom of the tide, causing the river entrance to shift radically up and down the beach.
- The entrance, once shifted to the south, causes excessive incursion of sand into the entrance.
- Redirection would change the entrance configuration, so the main channel would remain against the existing rock wall.
- The jet of water flowing with the tidal flow, instead of directly across it, would act as a venturi, significantly increasing the effect of the volume of water flowing out of the back channel and along the river near low tide.
- The shift into the corner would enhance these effects, as against simply redirecting the flow in the current location. This could be achieved for an estimated $500,000.

Several hours were spent with the Manager of Minor Ports and another local Lands officer looking over the concepts and ideas that had been developed at CW&F. The Manager considered that the proposal had merit and confirmed that our rough cost estimate would probably be in the ballpark.

Probably most telling from these discussions was a question in relation to what his department might be able to do: “So how many boats actually use this river entrance as a port?”. CW&F’s answer was that Stebercraft takes a few new ones out for delivery every year – not many. The reply was emphatic: “That’s about how many dollars I’ve got to spend on this minor port.” The manager who looks after NSW’s minor ports recognises the frequency of use that Harrington as a port actually attracts and has a budget for Harrington that is commensurate with that low frequency.

Even though he could see the merits in doing this minimalist project, his budgets would not extend to these costs for the very few boats that used the port of Harrington – fair call. This is where this story might have ended but for a beach fishing trip, and several beach walks where we could see first-hand the disturbing amount of coastal erosion on our beaches.

Recognising the links involved between the beach erosion and the river entrance mobility prompted this paper.

7 COASTAL EROSION

7.1 The Coast

Some knowledge of the area is needed to understand the proximity of the locations described in this section. The coast is the section where the Manning River enters the sea. The river system, a delta by definition, has two entrances: one at Harrington and the other at Farquhar near the village of Old Bar. The beach itself is one long sandy strip, although the sections of beach have different names. Crowdy Head is the headland at the northern extremity. Heading south, the next feature is the Harrington river entrance with its historic rock walls as described above. On the southern shore of this entrance is Mitchells Island, and the village of Manning Point is at the north-eastern corner of the island. The village is located about 4 km south of the break walls constructed in the late 1800s.

The next beach feature is the Farquhar entrance, the southern connection to the sea and the south-eastern corner of Mitchells Island. Farquhar is located about 8.5 km south of the village of Manning Point. About 3 km south of Farquhar is the village of Old Bar, so named because the bar had closed in the 1840s. There are a couple of reefs offshore at Old Bar that create a salient, first and second corner surf locations, that can be seen in Figure 20. The southern headland of this length of beach is at Wallabi Point. Saltwater Point, a well-known surfing break, is located 1.5 km further south of Wallabi Point.

Figure 20: Map of the Manning estuary coast (Nearmap image, August 2015).

7.2 Going Fishing at Manning Point

Manning Point provides an access onto the beach. The beach is usually a wide expanse of sand with a longitudinal gutter just offshore and sand banks beyond where the waves break. The beach access is also the primary access to the camping ground at Farquhar Park, the southern entrance of the Manning. Campers drive onto the beach, the length of Mitchells Island and camp just inside the entrance at the State Park Farquhar Inlet camping area.

Around August 2012, the author and fellow surveyor Matt McGuire prepared to go fishing for the Mulloway (jewfish) that frequent the gutter along Manning Point beach. The tides were right and we were looking forward to quite a few hours about the low and incoming tide, tight lines and a good catch. As we drove over the dunes to access the beach, we were confronted with a very narrow beach and waves almost lapping against the dunes. Stopping atop the dune access, we could see travel along the beach was limited. “Isn’t it supposed to be low tide?” Consulting the smartphone, we confirmed that low tide was still an hour or so away. We ventured a short distance toward the entrance and fished for a short time, retreating early when the tide changed and the incoming tide and waves started to make travel along the beach precarious. What was happening here?

7.3 Beach Walks and Photo Monitoring

To try to ascertain what was happening along this section of beach, several beach walks were done, photographing the beach erosion that was taking place between the access ramp at Manning Point and the entrance to the river on the northern tip of Mitchells Island.

Photographic monitoring was performed on four occasions:

- 11 September 2012.
- 6 May 2013.
- 4 July 2013.
- 25 June 2015.

The coast of Mitchells Island, a tad over 10.5 km long, is actually quite remote. There are basically three points of access onto the beach. The village of Manning Point has a dedicated 4WD beach access (Figures 21 & 22) and some of the local caravan parks have pedestrian access. Just over 4 km (4.3 km) south of the 4WD access is the end of Beach Road, where a small carpark and pedestrian walkway provides fishermen and walkers beach access. The access into the State Park Farquhar Inlet camping area is 3.5 km south of Beach Road.

During the period of beach monitoring, the 4WD access to the beach was restricted to low tide. To travel to the Farquhar camping area one had to wait until low tide before venturing onto the beach. Otherwise, waves were lapping against the base of the sand dunes and travel was not recommended (if not impossible). During this time, even walking along the beach at high tide was very restricted. Our photographic expeditions were always tide dependant.

7.4 Photo Beach Monitoring

Over this period, features photographed one time were completely gone the next. This made continuity of images difficult. For example, between 2012 and 2015, the beach at the 4WD access point receded, causing access to be reconstructed, each time a little steeper (Figures 21 & 22). Note that at least three panels of southern fence were gone, and the vegetation was suffering.

Figure 21: Manning Point access ramp, September 2012.

Figure 22: Manning Point access ramp, July 2015.

7.4.1 Photo Monitoring of the Northern Tip of Mitchells Island

Probably most telling of these on-the-ground images were those looking into the entrance (Figures 23 & 24 and through to Figure 33). The river entrance shifted south and ran into the end of the incomplete south barrier bank rocks placed around 1904 to protect the southern sand spit (i.e. the south training wall in Figure 12). The height of the dune is a testament to its usual location well behind the beach alignment. The proximity of the end of the rocks is clear. Harrington water tank can be seen on the hill behind.

Figure 23: Northern tip of Mitchells Island showing high dunes near the end of the rocks, September 2012.

Figure 24: Northern tip of Mitchells Island showing ocean waves breaking on the rocks of the northern end of the south barrier bank, September 2012.

From down near the rocks, looking upriver, trees have been left strewn about from the waves washing across the sand spit at high tide (Figure 25). The edge of a tuckeroo grove planted by the local Dunecare/Landcare group can be seen on the far left of the photograph. Rocks can be seen along the shoreline. Works around 1901-04 had placed the rocks to protect the southern sand spit. This was the start of the important barrier bank on the southern sand spit described by Coode (1889). Darley (1881) also described how the southern sand spit warranted rock protection with a stone dyke.

Figure 25: Looking upriver, September 2012.

By July 2013, all the high dunes had disappeared (Figure 26). Much more of the barrier bank rocks was visible extending out into the river. Waves break along the shore where the beach alignment now meets the river at these rocks. The eastern side of the tuckeroo grove can be seen on the left of the photograph adjacent the drop off to the beach.

Figure 26: Looking north, July 2013.

Looking back from the remnant rock wall in 2013, the grove of tuckeroo trees is right on the edge of the beach scarp (Figure 27). Waves have been flowing from the sea into the river between the rock wall and the vegetation on the spit.

Figure 27: Looking south, July 2013.

Looking back upriver from the northern end of the spit, the tuckeroo grove is on the left (Figure 28). Vegetation is still being strewn across the sand spit from wave action. The sections of the south barrier bank rocks can be seen along the edge of the river. Manning Point village is visible in the distance.

Figure 28: Looking upriver, July 2013.

By June 2015, the grove of planted tuckeroos was gone (Figure 29), and the remnant northern end of south barrier bank rocks can be seen much further from the vegetation than in 2013. The distance to the water tower at Harrington appears to be much greater than in 2012 (see Figures 23 & 24).

Figure 29: Looking north, June 2015.

Comparison with the 2012 photographs shows a disturbing amount of sand has been removed in the intervening 3 years. Closer to the entrance of the river, the expanse of sand between the vegetation and the rock wall is evident (Figure 30). Waves washing over the sand spit in 2015 have washed away the fallen vegetation from the beach. Again, the water tower at Harrington is visible in the distance.

Figure 30: Looking north, June 2015.

Looking south from the sand spit, it can be seen that the entire tuckeroo grove prominent only 2 years earlier had completely disappeared (Figure 31). Rocks from the barrier bank poked through the sand. The beach alignment to the south had marched even further westward since the 2013 images.

Figure 31: Looking south, June 2015.

Looking upriver south from the sand spit, the rock barrier bank can be seen along the edge of the river, with the village and pine trees of Manning Point in the background (Figure 32).

Figure 32: Looking upriver, June 2015.

Looking north, the expanse of the sand spit between the vegetation and the end of the rock barrier wall is evident. The end of the rock barrier was now well out into the river. Tops of small waves can be seen breaking along the shoreline.

Figure 33: Looking north across the sand spit, June 2015.

Upstream of the entrance, the inner side of the sand spit had also been devastated by the changes that occurred in the location of the entrance to the river (Figures 34 & 35). This is evidenced by the number of trees fallen into the river as we made our way back to Manning Point. Along the river side of the sand spit, significant erosion had occurred. Beyond the upstream limit of the southern barrier bank, large trees fallen into the river made moving along the foreshore difficult even at low tide.

Figure 34: River side of the sand spit, June 2015.

Figure 35: River side of the sand spit, June 2015.

This photographic record over 3 years from 2012 to 2015 shows what happened when the river shifted away from the northern sea wall around 2009/2011 and migrated south. At the southern extent of this shift, it has come up against the northern end of the incomplete south barrier bank rock wall. When the river entrance channel is flowing against the northern sea wall, this remnant section of south barrier bank rocks is about 300 m west of the beach alignment (Figure 36).

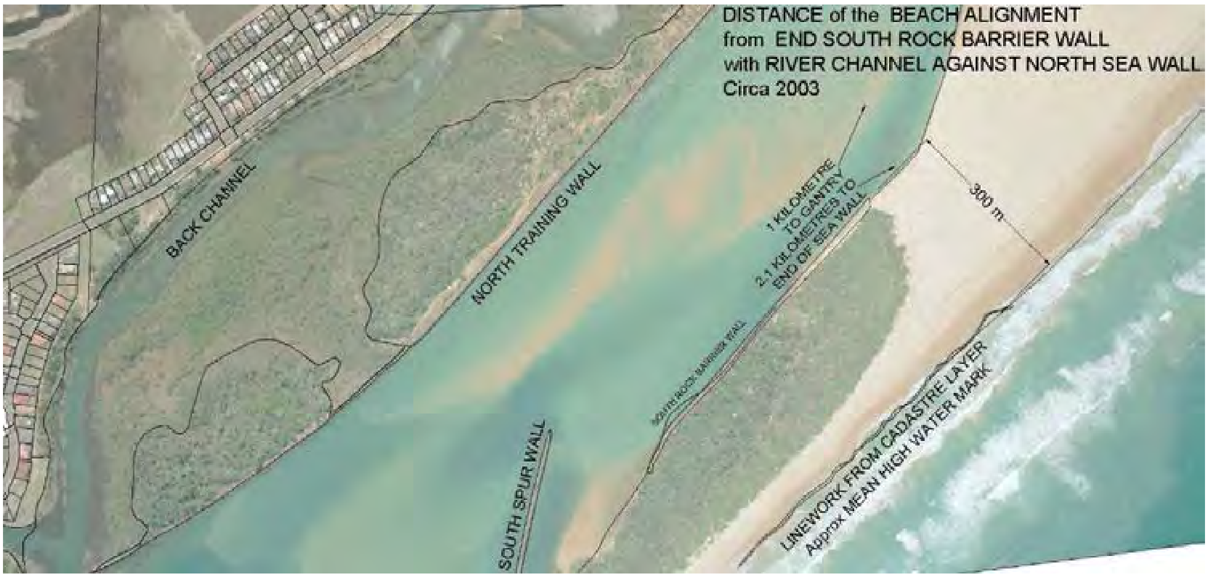

Figure 36: Beach near south barrier bank rocks, ca. 2003.

When the river flows interact with this remnant section of barrier bank rocks, tidal flows and waves cut off the beach in a south-westerly direction. The beach alignment has shifted landward by 300 m. Waves now break directly over these rocks that are usually on the river side of a wide sand spit (Figure 37). The original cadastre linework of the Mean High Water Mark (MHWM) can be seen out in the ocean waves well off the beach.

Figure 37: Aerial Nearmap image, September 2016.

7.4.2 Photo Monitoring of the Adjacent Beach of Mitchells Island

The photographs in the following figures show what was happening along the frontal dune system between the beach access and the river entrance during this time. The erosion along the beach is obvious. The scarp in 2012 was not full height. The peak of the foredune is behind and higher (Figures 38 & 39).

Figure 38: Adjacent beach of Mitchells Island, September 2012.

Figure 39: Adjacent beach of Mitchells Island, July 2013.

The sand scarp is nearing the peak of the foredunes all the way along the beach. On a human scale, the dunes are quite high in places. The wave action at the toe of the dune is evident by the lack of debris. The whole beach front is actively eroding, and the erosion scarp appears to be at full height of the dunes (Figures 40 & 41).

Figure 40: Adjacent beach of Mitchells Island, July 2013.

Figure 41: Adjacent beach of Mitchells Island, June 2015.

Closer to the river entrance, coastal littoral rainforest trees were dropping onto the beach (Figure 42). Large trees still on the dunes were suffering from exposure to the prevailing winds (Figures 43 & 44).

Figure 42: Coastal littoral rainforest trees dropping onto the beach, September 2012.

Figure 43: Trees suffering from exposure to the prevailing winds, May 2013.

Figure 44: Trees suffering from exposure to the prevailing winds, July 2013.

By 2015, large sections of the fontal dunes were gone. In Figure 45, the tall trees and water tank of Harrington village can be seen across the river entrance to the sea.

Figure 45: Tall trees and water tank of Harrington village across the river entrance, June 2015.

From these figures, it is evident that the foredunes along the front of Manning Point beach from the beach access to the river have eroded dramatically in this period as the whole beach front remained connected to the 300 m shift in the beach alignment at the northern tip of Mitchells Island at the south barrier bank rocks. Beach erosion south of the beach access has also occurred in this same time frame.

Could it be that the entire beach, 16 km long, all the way to Wallabi Point might be trying to realign to this changed northern point 300 m west at the tip of the incomplete south barrier bank rocks?

Could the erosion we have experienced on this part of the coast, some of the worst in NSW, be the result of the Manning River interacting with this small section of incomplete rock bank protection abandoned in 1904 by PWD?

7.5 Smiths Beach Coastal Erosion

Smiths Beach, partway along Mitchells Island, is a popular fishing spot. At the end of Beach Road is a small carpark and a sandy pedestrian access track. At Smiths Beach, 3.2 km south of the south barrier bank rocks, the beach scarp progressed about 10 m westward, from 81 m 2011 to 70 m in 2016 (Figures 46 & 47). The lines seen in the images are the cadastral layer in the Nearmap imagery.

Figure 46: Smiths Beach (Nearmap image, September 2011).

Figure 47: Smiths Beach (Nearmap image, August 2016).

7.6 Old Bar Beach Coastal Erosion

Closer to Old Bar, a small reef (Urara Reef) lies just offshore, which creates good surf breaks. The energy lost by the waves breaking around the reef creates a salient. The surf breaks are known as first and second corner, named as such from the apparent bend in the alignment of the beach behind the reef. At second corner, there is a carpark, shower and (there was) a 4WD timber slat access ramp onto the beach, used to beach-launch small fishing boats. A viewing platform was constructed on the edge of the dune to check out the surf and limit damage to the dune (Figure 48).

Figure 48: Second corner beach access and viewing platform (Nearmap image, 2011).

Between 2011 and 2015, the entire timber access ramp and viewing platform disappeared (Figure 49).

Figure 49: Second corner beach access and viewing platform disappeared (Nearmap image, 2015).

In 2018, a near vertical drop was evident. Council's GIS airborne laser scanned contours provide an elevation higher than 14 m (AHD) at the top of the dunes (Figure 50). By 2022, the top of the beach scarp had progressed beyond the top of the foredune and was starting to reduce in height down the rear of the dune (Figure 51).

Figure 50: Second corner (Nearmap image, 2018).

Figure 51: Second corner (Nearmap image, May 2022).

Like the beach at Manning Point, it is difficult to quantify the erosion simply because there is little built infrastructure in the area. What was there is now simply gone! It is sufficient to say that in this 10-year period significant erosion has taken place at the second corner access track. (Measurements from the edge of the nearby road to the toe of the scarp indicate about 133 m in 2011 and about 113 m in 2022, i.e. a change of about 20 m.) The second corner access track is 12.2 km south of the tip of the southern bank barrier rocks at Manning Point and 4 km north of Wallabi Point.

Between the villages of Old Bar and Wallabi Point, there is a disused sand quarry that now contains the Old Bar Waste Water Treatment Plant (WWTP) sand infiltration ponds. Between September 2011 and May 2022, the distance from the pump house to the edge of the dune scarp reduced from about 170 m to about 151 m, i.e. by almost 20 m (Figures 52 & 53).

Figure 52: Old Bar WWTP sand infiltration ponds (Nearmap image, September 2011).

Figure 53: Old Bar WWTP sand infiltration ponds (Nearmap image, May 2022).

For MidCoast Council, this is an important facility because it effectively caters for the waste water from a couple of important seaside villages. This waste water facility is 15.3 km south of the tip of the south barrier bank rocks and 950 m north of Wallabi Point.

7.7 Coastal Erosion Conclusion

The investigation has shown that significant erosion (300 m) occurred where the Manning River has shifted in location south and interacted with a remnant section of what Coode described as "barrier bank to south spit". This work, abandoned in 1904, is a small section of rock wall that appears to have a dramatic effect on the alignment of the beach. The erosion appears to occur for the full length of the beach, as the beach tries to align with the changed location of the northern end (Wallabi Point is 16 km south of the entrance). In the village of Old Bar, several houses have been lost to this beach erosion.

The key question is: Could the erosion noted all the way along this beach be ameliorated by stabilising the Manning River entrance against the Harrington sea wall? Would limiting the interaction of the entrance with the south barrier bank rocks ameliorate the beach erosion?

Just to put a figure on the value, let us say the toe of the foredune shifts about 20 m if it averages a height of 5 m. This results in a loss off the dunes of 100 m^3 per metre over 16 km, i.e. 1,600,000 m^3 of sand. Local suppliers give sand a value over $80/$m^3$ wholesale, putting a dollar value of $128 million on these losses. However, the coastal foredunes have a much greater intrinsic value to the people and environment adjacent to the coast. Surely, it is worth a small investment to protect them!

7.8 Historic Coastal Erosion

The 1990 Coastline Management Plan for Racecourse Creek / Lewis Street, Old Bar (PWD, 1990) was produced after noticeable erosion had been occurring in the vicinity. PWD had done a photogrammetric analysis of the beach profile in 1989. Obviously, this most recent erosion event recognised by the river flows interacting with the south barrier rock wall, which occurred around 2009, could not have influenced the erosion that caused Council to employ PWD to analyse the aerial photographs, report and provide a Coastline Management Plan.

The Coastline Management Plan did, however, report on the erosion and the analysis of the occurrence. There were variations through changes to Racecourse Creek, but for areas away from the creek, the PWD report provides the following commentary (PWD, 1990): "On the open coast south of the creek entrance, the profile information indicates that the frontal dune was advanced seaward by up to about 10 m during the period 1940-1965. Between 1965 and 1989 the shoreline has progressively receded. Most of the recession has occurred within the 30 m road reserve located east of the allotments fronting Lewis Street."

The Coastline Management Plan further indicates that the erosion seemed to start in about 1965: "During the period 1965-1989 recession trends indicate a mean of approximately 0.2 metres per annum with a maximum up to 0.3 metres per annum at individual locations." Prior to 1965, from 1940 onward, the frontal dune was 10 m further out.

The 1965 aerial photograph shown in Figure 54 indicates that a similar southern migration of the river entrance had occurred at some time prior to 1965:

- The northern rock sea wall is covered by beach sand.
- The main channel of the river appears to be directly in front of the gantry opening.
- The river has interacted with the northern tip of the southern barrier bank rocks.
- The tip of the rocks is visible near the southern most channel in this image.
- The face of the beach has been torn off almost exactly as it has been around 2016 (Figure 55).
- Vegetation on the coast between Manning Point village and the river entrance has been stripped back to a slender island of dark-coloured vegetation.
- In comparison, the vegetation strip in 1965 (Figure 54) appears to be even more slender than in 2016 (Figure 55).
- Significant influx of sand into the river channels upstream of the entrance and south spur wall has occurred with the entrance in this southern location.

Figure 54: Aerial photograph of Harrington entrance, 1965.

Figure 55: Aerial photograph of Harrington entrance (Nearmap image, 2016).

Similar points can be seen in the aerial photograph of 1969 (Figure 56). Looking at these images from the 1960s, one might expect that coastal erosion similar to that recorded between 2012 and 2015 and presented earlier in this paper would have occurred along the coastline in the late 1960s. PWD (1990) recorded that erosion commencing around 1965 at Old Bar. It is a pity that they did not look up the beach to Manning Point to find a reason for this behaviour.

Figure 56: Aerial photograph of Harrington entrance, 1969.

7.9 Historic Imagery

The aerial photograph of December 1972 (Figure 57) shows that the main river flow had started to migrate back toward the northern sea wall, which is still buried by beach sand for much of its length. The plume of sand in the back channel from the gantry flows is clearly visible. The main river channel is just downstream of the gantry. The width of the southern spit had started to recover. The vegetation on the spit appears to have started to take hold once again. There is a thin line visible that probably indicates the sand scarp location visible in the 1965/69 aerial imagery.

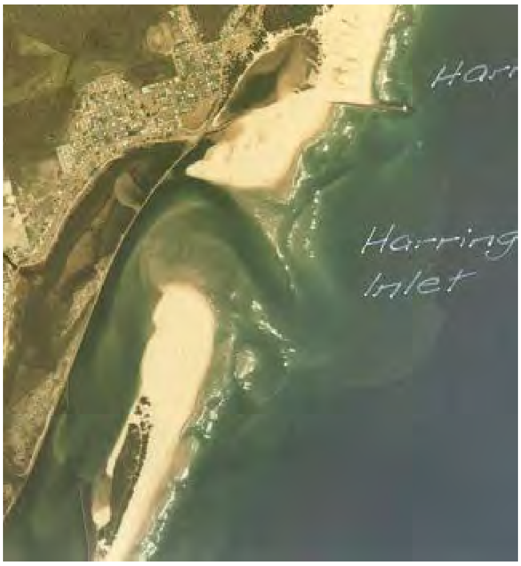

Figure 57: Aerial photograph of Harrington entrance, December 1972.

The series of aerial photographs in Figure 58 shows the recovery of the river channel back to the sea wall and subsequent shifts over time. The cadastral line work visible in these images is the same shown in part in Figures 36 & 37.

Figure 58: Aerial photographs showing the recovery of the river channel over time.

7.10 Commentary on Historic Imagery

The historic aerial images show the amazing recovery of the beach alignment from 1969 to 1972, which indicates the 300 m width of sand east of the remnant barrier bank rocks had been restored. What happens to the alignment of the remainder of the beach when this occurs is hard to determine and beyond the scope of this paper. Suffice to say that the mobilisation of over a million cubic metres of sand from the dunes is not considered a beneficial process. The images clearly show the significant changes that take place in this river entrance.

In 1997, the river had once again shifted south, with the south barrier bank rocks just starting to impact the flow. The alignment of the beach was again under threat. What occurred over the length of the beach to Wallabi Point at this time is unknown. It is interesting to note that the sand built up over the wall in the 1997 image has a beach alignment similar to that of the cadastral linework. This is also similar to the beach alignments that are shown on the historical maps from 1862, 1879 and 1888 (see Figures 8-10). This indicates that the natural stable beach alignment is in approximately this location.

By 2005, the river had migrated north again, the full beach width about 300 m wide appears to be present at the location of south barrier bank rocks. These images only provide a snapshot in time, and the fluctuations between the images are hard to discern. Times of flood or freshet can make dramatic changes that are not specifically related to these images. To see if patterns occur, several images have been overlayed on the cadastre and the sand banks traced to see if a trend might be discerned. The following is one potential scenario.

In Figures 59 & 60, there is a build-up of sand in front of the gantry. At the bottom of the tide, the jet of water coming out of the gantry is potentially blocking the last of the river's outgoing tide. This minor blockage over several tidal cycles has the potential to cause the upstream channel to meander. Between 2003 and 2006, the upstream channel meandered about 100 m.

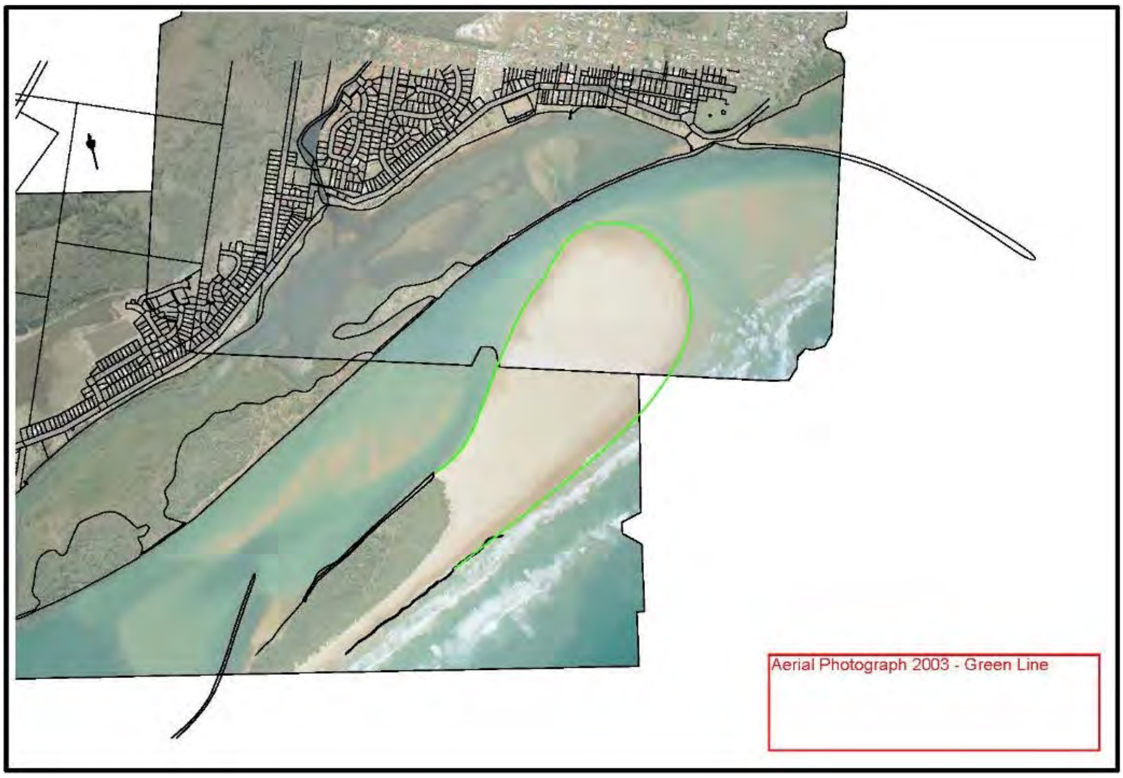

Figure 59: Aerial image (2003) overlayed on the cadastre and the sand bank outlined green.

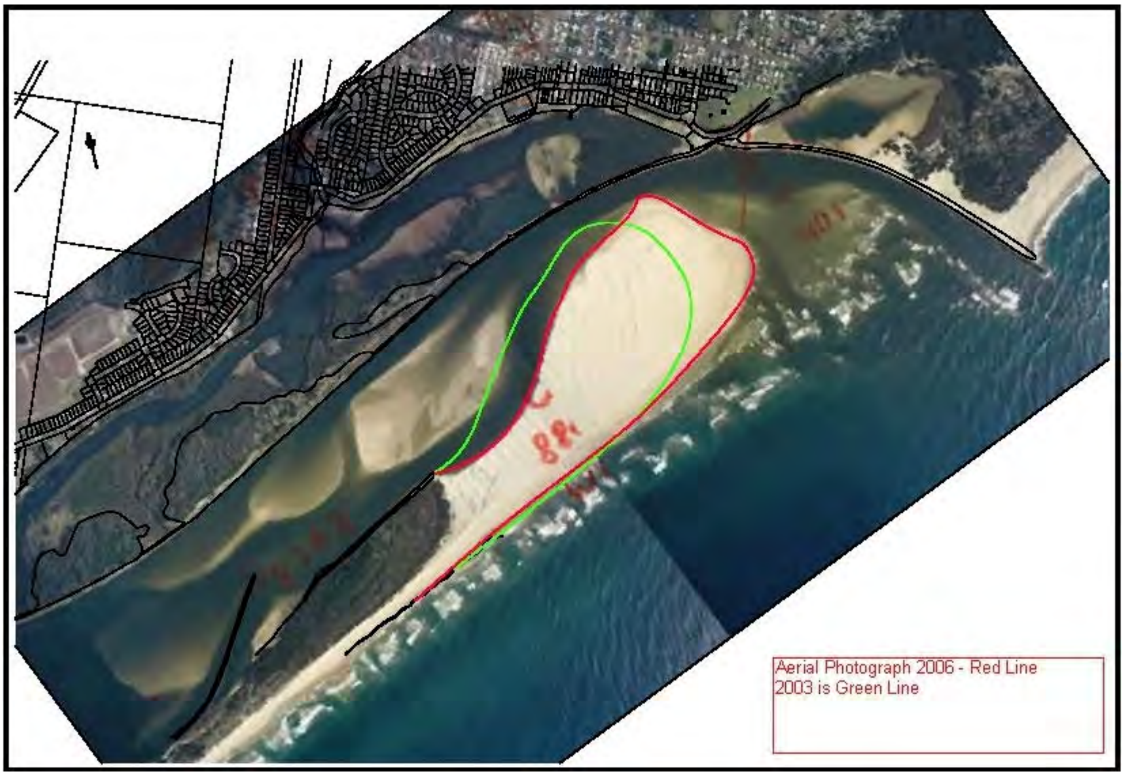

Figure 60: Aerial image (2006) overlayed on the cadastre and the sand bank outlined red.

The July 2009 aerial image (Figure 61) depicts the continued migration of the southern shore of the river eastward. From the 2003 shoreline, it has travelled almost 300 m closer to the ocean. Channels across the beach in this image show signs that the sand spit has been over-topped, probably by flood water. The beach alignment has receded marginally. The channel against the north break wall remains restricted. Council records show significant flows were encountered in the catchment in April and September 2008 and also in February and May 2009, not long before the image in Figure 61 was flown in July. Minor flooding also occurred in October and November 2009 and in December 2010.

Figure 61: Aerial image (July 2009) overlayed on the cadastre and the sand bank outlined blue.

Lines depicting the extent of vegetation traced from the 1965 and 2005 aerial images have also been added to this image. Between 2005 and 2009, the vegetation band along this section of Manning Point beach had actually progressed marginally seaward. At the minimum, the 2005 vegetation line is more than 50 m east of the 1965 vegetation strip. At the northern tip of the 1965 vegetation strip, the vegetation in 2009 is over 200 m seaward, indicating good dune recovery occurred in that time period.

7.11 Imagery 2011 to 2021

A major flood occurred in June 2011, not long before the image in Figure 62 was taken. It is unknown whether the river had broken through the beach before this time. One might postulate that the reduced channel by the north wall and reduced width of the southern sand spit has allowed the river to break through the sand spit and migrate radically south. The river entrance is flowing through the entire area between the northern tip of the south barrier bank rocks and the north break wall, i.e. a distance of 2.1 km.

Figure 62: Aerial image (Nearmap, September 2011) overlayed on the cadastre and the sand bank outlined.

The frequency of available imagery and its resolution has increased dramatically in the past decade. The following images show changes at Harrington between 2011 and 2021 (Figures 63-65). A major flood occurred in the Manning on 20 March 2021, only a couple of weeks before the image of 9 April 2021 (Figure 65) was flown. The reduction in sand noticeable in the inlet can be explained as a result of this flood event.

Figure 63: Aerial image (Nearmap, 2016) overlayed on the cadastre and the sand bank outlined.

Figure 64: Aerial image (Nearmap, 2019) overlayed on the cadastre and the sand bank outlined.

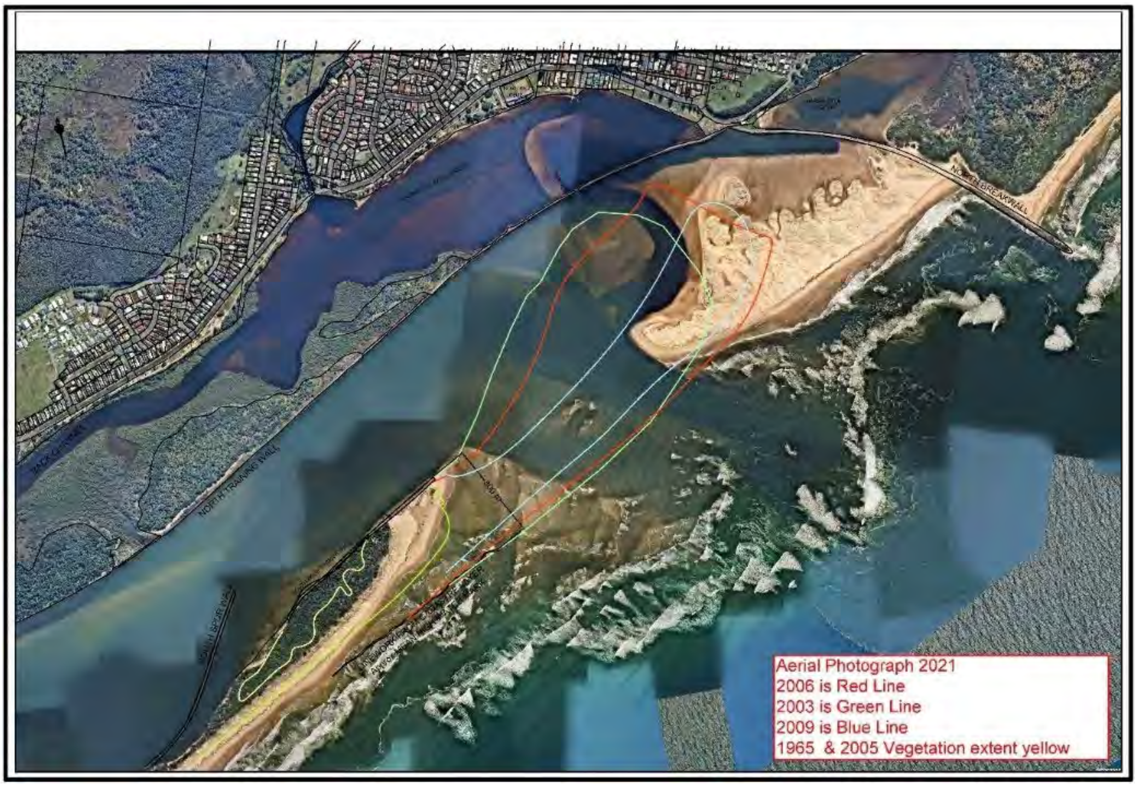

Figure 65: Aerial image (Nearmap, 2021) overlayed on the cadastre and the sand bank outlined.

In summary, the following can be deducted from these images:

- The river continues to flow adjacent to the northern tip of south barrier bank rocks.
- The beach alignment south is still connected to the tip of the south barrier bank rocks (300 m west of its natural location, ca. 1972-84 and 2003-06).
- The adjacent vegetation strip has reduced in size continuously since 2011.
- Significant sand influx into the entrance is notable. The southern location of the entrance has promoted greater deposition of sand upstream of the spur wall.
- The beach alignment of sand covering the north break wall is similar to the beach alignment in 2003 (green) and 2006 (red), indicating that this is the natural location of the beach alignment (as it has been since the earliest surveys of the estuary, see Figures 8-10).
- Deep flow channels, in front of the gantry, are evident, prominent and significant for over 10 years since the 2011 aerial image.

Regarding the “elegantly simple solution”, now imagine the gantry flow, which is generating these deep flow channels, being relocated to near the notch in the corner of the wall, under Pilot Hill, and directed along the face of the northern break wall.

It is the contention of the author that energy coming through the gantry, so obvious in these images, directed in that way would produce a very different and much more desirable outcome for the river and indeed the coastline all the way to Wallabi Point.

8 LOCATION VS. SAND INFLUX AND DEPOSITION IN THE ESTUARY

As noted above, the variation in location of the entrance configuration changes the area in which sand is deposited into the estuary. This is relevant for both the Harrington and Farquhar entrance configurations. In a greater area, there is potential for more sand to be deposited inside the estuaries, which detracts from the available sand on the beaches. To assess this, circles of 1.2 km radius have been drawn centred on the apparent entrance locations. This represents a reasonable travel distance before sand mobilised off the beach would be deposited. An area is then calculated within the estuary and this circle.

For Harrington, the 2009 and 2014 images were used with the entrance located (Figure 66):

- North – Area of deposition: 48 ha.
- South – Area of deposition: 105 ha.

With the entrance located in the south, by the south barrier bank rocks, the area of sand deposition within the estuary is over twice that of when the entrance is in the north near the northern breakwater. The implication of this at Harrington is that the northern entrance location is by far the preferred location in respect to sand that is deposited into the estuary and lost to the surrounding beaches.

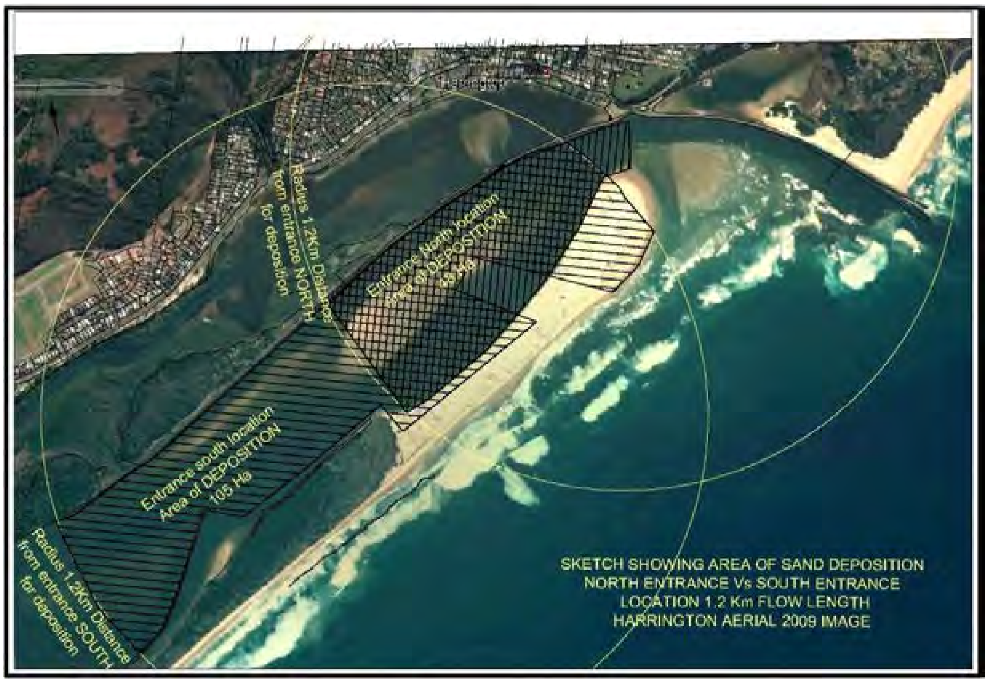

Figure 66: Sand deposition areas at Harrington.

A similar exercise was performed for Farquhar, using the 2011 image with the entrance located (Figure 67):

- North – Area of deposition: 139 ha.
- South – Area of deposition: 78 ha.

With the entrance located in the south by the soft rocks, the area of sand deposition within the estuary is almost half that of when the entrance is located in the north. Therefore, at Old Bar, the southern entrance location is by far the preferred location in respect to sand that is deposited into the estuary and lost to the surrounding beaches.

Figure 67: Sand deposition areas at Farquhar Inlet, Old Bar.

The Farquhar Inlet Old Bar Entrance Opening Management Plan provides a strategy for opening the entrance at Old Bar when it closes. There are environmental and flood triggers that, when activated, allow for mechanical opening of the river to the ocean. These observations in relation to potential sand deposition may assist in determining the location selected to open the entrance. The sand shoals in Farquhar (see Figure 67) are now making it difficult to navigate other than at high tide. Even the smallest tinny can struggle to get around the estuary. Historically, the steam ship Electra (see Figure 13) would take people to Farquhar campground for bridal races, community gatherings and picnics on the beach spit, so this is a significant change.

There may even be a correlation between the two entrances and the relative location of each, but this is beyond the scope of this paper. Once in the estuary, other than floods, only a significant dredging program can re-establish the sand back onto the beach alignment. Replenishment of our beaches in this way may still be an option in the future.

9 COMPILATION OF STUDIES ON THE MANNING RIVER

This section lists a non-exhaustive compilation of studies that have been conducted in and around the Manning and this estuary. In the late 1990s, Council was intent on doing another study. From memory, the stated value of the proposed study was in excess of $450,000. This was about the same amount as that required for the proposals discussed with local earthmoving contractor Mills Earthmoving. CW&F argued that the entire cost of their proposal would likely be less than the cost of the computer modelling. Why don't we do the modelling in real life? We were assured that such studies need to be done and that the "elegantly simple" proposal would be modelled in order to prove that it works. Unfortunately, this has never occurred and the only references to the "elegantly simple solution" have been unsubstantiated opinions (DPI, 2018).

Some of these studies did do amazing things. The numerical modelling produced incredibly natty simulations of sand influx and salinity increases after flooding. However, they did not do anything for the river! Unlike life, where there are no guarantees, there is an iron-clad guarantee in relation to these studies. We can absolutely, hand on heart, guarantee that if another study is done, absolutely nothing will change in the river or on our beaches.

Since the discussions with Council and the Manager of Minor Ports at the former Department of Lands, who had no budget for Harrington port, numerous studies have been performed. The cost of these studies has probably exceeded the cost of initiating and completing the "elegantly simple solution" several time over.

The following is a non-exhaustive list of studies on the Manning River:
- Forde's survey (1862).
- Sydney's survey (1879).
- Engineer's report by C.W. Darley (1881).
- Carleton's survey (1888).
- Manning River report by John Coode (1889).
- Hydrographic survey (1906).
- Report minutes of evidence and plan relating to proposed completion of harbour works at the entrance to the Manning River, Parliamentary Standing Committee on Public Works (July 1910).

- Hydrographic survey (1912).
- Old Bar coastal erosion study, Sinclair Knight and Partners (SKP) (draft, August 1982).
- Manning River entrance study: Background & issues of concern, PWD (1987).
- Old Bar photogrammetric analysis, PWD (November 1989).
- Coastline management plan for Racecourse Creek / Lewis Street, Old Bar, PWD (October 1990) – includes provision of a 100-year impact line plan.
- Manning River estuary processes study, Webb, McKeown & Associates (September 1997).
- Quaternary geology of the Forster-Tuncurry coast and shelf, southeast Australia, Geological Survey of NSW (December 1997).
- Manning River hydrographic survey 1999, Department of Lands and Water Conservation Estuary Management Program (August 2000).
- Manning River estuary management study, numerical modelling, discussion paper and final report, WBM Oceanics Australia (December 2000).
- Proposed dredging of the Manning River for Harrington Waters Estate, Harrington, environmental impact statement, WBM Oceanics Australia (February 2002).
- Manning River entrance improvement project: Economic scoping study, Rolyat Services (April 2003).
- Manning River entrance at Harrington: Review of economic scoping study for southern break wall, Department of Infrastructure, Planning and Natural Resources (2003).
- Manning River estuary management study, Worley Parsons (July 2009).
- Farquhar inlet, Old Bar entrance opening management plan, Worley Parsons (May 2010).
- Greater Taree coastline management study: Black Head to Crowdy Head, Worley Parsons (October 2010).
- Manning River maintenance dredging strategy, Greater Taree City Council (August 2010 & May 2015).
- Coastal zone management plan for Greater Taree, Worley Parsons (March 2013).
- Old Bar beach coastal protection structure design investigation, Royal Haskoning (December 2013).
- Cost benefit analysis of options to protect Old Bar from coastal erosion, The Balmoral Group – Australia (August 2014).
- Manly Hydraulics Laboratory slides, G. Calvin (May 2015).
- Manning Point beach photo monitoring (July 2015).
- Harrington Waters dredging project final environmental management report, Umwelt (September 2015).
- Old Bar beach sediment tracing, Royal Haskoning (draft, July 2015).
- Erosion analysis of the Manning Valley coastal sediment compartment, Report MHL2408 (March 2017) – marked “not for release”.
- Manning River entrance investigations: Manning River southern breakwater feasibility study, Manly Hydraulics Laboratory (September 2018).
- The Manning River floodplain risk management study and plan, MidCoast Council (2019).

The remarkable outcome of most of these studies is the recommendation to do yet another study! For example, a common theme is: “Any feasible option worthy of further consideration will require additional investigations” (DPI, 2018). There is a plethora of information buried in these reports and studies. Much is said about coastal processes, fluvial inputs, sediment sinks, longshore littoral transport and much conjecture is made about anthropogenic influences. When making comparisons, these studies always start with a “do nothing” option.

The observations documented in this paper indicate that the current status of Harrington estuary is extremely detrimental to the river, beaches and coastline of the Manning. Unfortunately, none of these studies actually recognise the damaging and detrimental effect and environmental cost of the "do nothing" option.

10 CONCLUDING REMARKS

Faced with this mass of highly educated writings from exalted engineering companies with double-barrel names or 3-letter acronyms, one feels like the little boy in the fairy tale when he says: "Look Ma, the emperor has no clothes on!" This paper has shown that the greatest anthropogenic influence on the river entrance and very likely on the coastline compartment from Crowdy Head to Wallabi Point is the unfinished rock wall, left incomplete north of Manning Point by PWD in 1904 (McNeil, 2011b).

In summary, photographic evidence provided in this paper shows:

- When the river entrance shifts to the south, it interacts with the unfinished south barrier bank rocks (see Figures 23-33).
- This interaction causes the beach alignment to shift westward 300 m to the northern tip of the incomplete south barrier bank rocks (see Figures 36 & 37).
- The remaining beach south erodes dramatically as it tries to maintain a connection to this new location at the rocks, now 300 m inland of its natural status (see Figures 38-41).
- Coastal littoral rainforests are destroyed (see Figures 27-35 and 42-44).
- The coastline south for 16 km to Wallabi Point appears to be similarly affected by this shift in the northern end of the beach alignment (see Figures 46-53).
- Archival aerial photographs show that there has been a cycle of this southerly shift in the river entrance, i.e. 1965-69, 1997-??, and 2011-22 and continuing (see Figures 54-58 and 62-65). This is consistent with the unstable nature of the recent erosion history of this beach.
- This fluctuation in the beach alignment causes erosion of the frontal dunes with mobilisation of over a million cubic metres of sand in this recent event. There is immeasurable damage to our coastline.
- The economic and environmental cost of this damage is not registered as part of any "do nothing" option in any of the studies listed above.
- This cause and effect is not mentioned in any previous studies. How did they miss it?

This paper has investigated the historic engineer's reports from Darley (1881) and Coode (1889) and compared the outcome of the works with the plan and reports (see Figures 11 & 12):

- Both Darley and Coode (more than 130 years ago) recognised the importance of protecting the south sand spit. Darley's "dyke of stone" proposal is 1.5 miles (2,414 m) long, while Coode's "barrier bank to south spit" is 6,700 feet (2,042 m) long. The existing rock rubble facing on the south spit is only 700 m long (see Figure 12).
- It is this short piece of unfinished south barrier bank rock that interacts with the river, causes the beach alignment to shift 300 m landward and results in dramatic and excessive beach erosion.
- Coode's plan did not include a north training wall upstream of the 'Painted Rocks' at the corner under Pilot Hill. Darley's report calls for a "training dyke about ¾ of a mile in length" (1,207 m).

- The north training wall ended up 2,900 m long (see Figure 12). One might ponder, had this rock been used to do the important south sand spit work, this entire conversation may not be necessary.
- Coode's plan, promoted as the design in the early 1890s (see Figure 11) and still being promoted as the design in DPI (2018), bears little resemblance to the break walls and training walls in place today (see Figure 12).

Ah, but there is a possible solution! As stated by Engineer Bruce Collins on 15 June 1999, the "solution is elegantly simple and utilises existing structures without major works. The work involved in implementing this solution means that costs will be limited." In summary, this includes the following:

- The evidence for the hydraulic energy, proposed to be redirected in the "elegantly simple solution", is found in the photographs provided.
- The sand plume in the backwater locates the gantry. The energy in the flow coming out of the gantry interacts with the river and forms flow channels through the sand shoals.
- These flow channels can be seen in Figures 17, 54, 55, 57, 58 (1997), 63, 64 and 65.
- It is not hard to imagine how different those figures might look if these flow channels were relocated near the notch in the corner, rather than at the current gantry location.
- Now, while the proposed location is located in quiet backwater, is the time to get in and do the construction. Waiting until this section is part of the full river flow will make the job so much more difficult.

One might ponder if the "elegantly simple solution" had been taken up back in 1999, could the houses since lost to beach erosion in Old Bar still be there?

One can only hope that the author does not find himself revisiting this same situation again in another 20 years. This paper has clearly shown that "do nothing" is not an environmentally valid option.

It would be a shame to have to continue witnessing the destruction of our beaches and coastline environment into the future.

ACKNOWLEDGEMENTS

Bruce Collins, gentleman, surfer, engineer, mentor and friend, passed away in the ocean at Forster in April 2022. His contribution to this paper was considerable, looking at the photographic evidence together, sharing ideas and encouraging and developing rational engineering concepts out of vague ideas, and promoting and supporting those ideas and concepts for the good of the community and environment. Vale Bruce Collins.

The author also acknowledges and thanks Peter Calabria for his time, capabilities and computing power with photographic manipulation before Photoshop made it de rigueur, Karl Bayer (photographer and fellow beach fisherman) for providing his high-quality aerial images, Lee Kiernan (chainman, friend and a good laugh on many a survey job) and staff at MidCoast Council who have assisted with editing and producing this paper.

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Discussion Forum: Live NSW and the Spatial Digital Twin

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ABSTRACT

The Live NSW program, including the NSW Spatial Digital Twin (SDT), is set to transform the way surveying and geospatial professionals access, create, validate and contribute data to the broader NSW data ecosystem. At its core, the uplift of foundation spatial data from 2D to 3D and 4D (time) is a challenging and ambitious goal that depends on continued government, industry and research collaboration. This discussion forum highlights the key initiatives that form part of, or relate closely to, the Live NSW program, and the impact they will have on industry. These include (1) digital survey plans and the role of surveyors in realising a digital property development pipeline, (2) a state-wide adjustment for the NSW survey control network updated in near real-time to underpin greater industry productivity, (3) the role of the Spatial Digital Twin in improving community engagement in the planning and delivery of infrastructure, (4) using foundation spatial data to support emergency responders and create more resilient and sustainable communities, and (5) the ability to measure accurate Australian Height Datum (AHD) heights via Global Navigation Satellite System (GNSS) positioning using an improved geoid model created from the NSW gravity model. This forum also outlines the approach DCS Spatial Services is taking to better align activities with customer needs and foster innovation.

KEYWORDS: *Live NSW, Spatial Digital Twin, digital survey plans, survey control, gravity model.*

Railway Boundary Definition and Problems Encountered

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ABSTRACT

In NSW, before registering a Deposited Plan (DP) that contains a definition of a boundary adjoining a rail corridor, Land Registry Services (LRS) requires that approval of that definition be obtained from Transport for NSW (TfNSW) acting on behalf of the Transport Asset Holding Entity (TAHE). As TAHE is a relatively new instrumentality, this paper first discusses its working relationship to TfNSW. Updated contact details for requesting an approval of a rail boundary are also advised. About 1 in 10 rail boundary approval requests are returned at least once to the requesting surveyor for clarification or amendment. In an attempt to reduce this number, this paper then presents examples of those plans that were returned to the surveyor and outlines the reasons why.

KEYWORDS: *Railway, cadastral boundary, approval.*

1 INTRODUCTION

NSW Land Registry Services (LRS) create and maintain land title records on behalf of the NSW Government (LRS, 2023). Before registering a Deposited Plan (DP) that contains a definition of a boundary adjoining a rail corridor, LRS requires that approval of that definition be obtained from Transport for NSW (TfNSW), acting on behalf of the Transport Asset Holding Entity (TAHE).

TAHE was formed in July 2020 and is now the owner of a portfolio of railway assets across NSW, including tracks, stations and extensive land holdings (TAHE, 2023). It is now the authority that approves the definition of railway boundaries. LRS guidelines on the issue of railway boundaries can be ambiguous. Often a plan is submitted for review that probably is not strictly in accordance with the requirements of the guidelines.

About 1 in 10 rail boundary approval requests are returned at least once to the requesting surveyor for clarification or amendment. In an attempt to reduce this number, this paper presents examples of those plans that were returned to the surveyor and outlines the reasons why.

Information on Working Plans can be useful when re-establishing railway boundaries. If using Working Plans, the publication "Definition of railway boundaries in NSW" (Webber, 1983) is an essential guide. Boundaries that are shown as curved on Working Plans are often arbitrarily converted to straight line boundaries upon survey of the adjoining land. Generally this is un-acceptable, as shown in the case studies presented in this paper.

Most railways in NSW were constructed in the late 19th and early 20th centuries. Land was acquired by gazettal rather than survey, and confused boundaries can often be the result, as this paper shows.

2 SUBMITTING A PLAN FOR REVIEW AND APPROVAL OF A RAILWAY BOUNDARY

TAHE has delegated responsibility for approving railway boundaries to the Property Group in Sydney Trains, which is one of TAHE's partners. Consequently, Sydney Trains surveyors assist with the reviews. Plans should be sent for review and approval to the following email address: property_gis@transport.nsw.gov.au.

Current staff include (all contactable via the email address above):
- Sandy Lam – Property Information Manager
- Daniel Prior – Senior Property Information Officer
- Rodney Varlet – Property Information Officer

Surveyors involved in the process include:

• Ian Jones	ian.jones@transport.nsw.gov.au	0413 005 420
• Gary Clifford	gary.clifford@transport.nsw.gov.au	0412 145 094
• Alex Burridge	alex.burridge@transport.nsw.gov.au	0413 852 810

3 CASE STUDIES OF PLANS THAT PROBABLY SHOULD NOT BE COMING TO TAHE FOR APPROVAL

3.1 LRS Guidelines

Where land is bounded by railway land, consent by Sydney Trains will be required, unless the boundary is either:
- based on (and identical to) a boundary shown in a previous plan that bears the consent of RailCorp / TAHE, or
- defined by existing registered DPs, portion plans or section plans, and
- the surveyor's definition of the railway boundary maintains that definition without excess in side boundaries to the railway boundary, and
- the definition is supported by evidence of railway occupations.

3.2 Survey at Quirindi

Figure 1 shows a recent survey of the rail corridor at Quirindi. The following points are to note:
- The fix of George Street agrees with DP1052162 and DP89803 and is related to State Survey Marks (SSMs) vide DP1052162.
- SSM-to-boundary connections are all per original, and lot depths George Street to railway are all per original.
- There is a consistent azimuth difference to previous plans.
- The surveyor was requisitioned to provide rail consent.

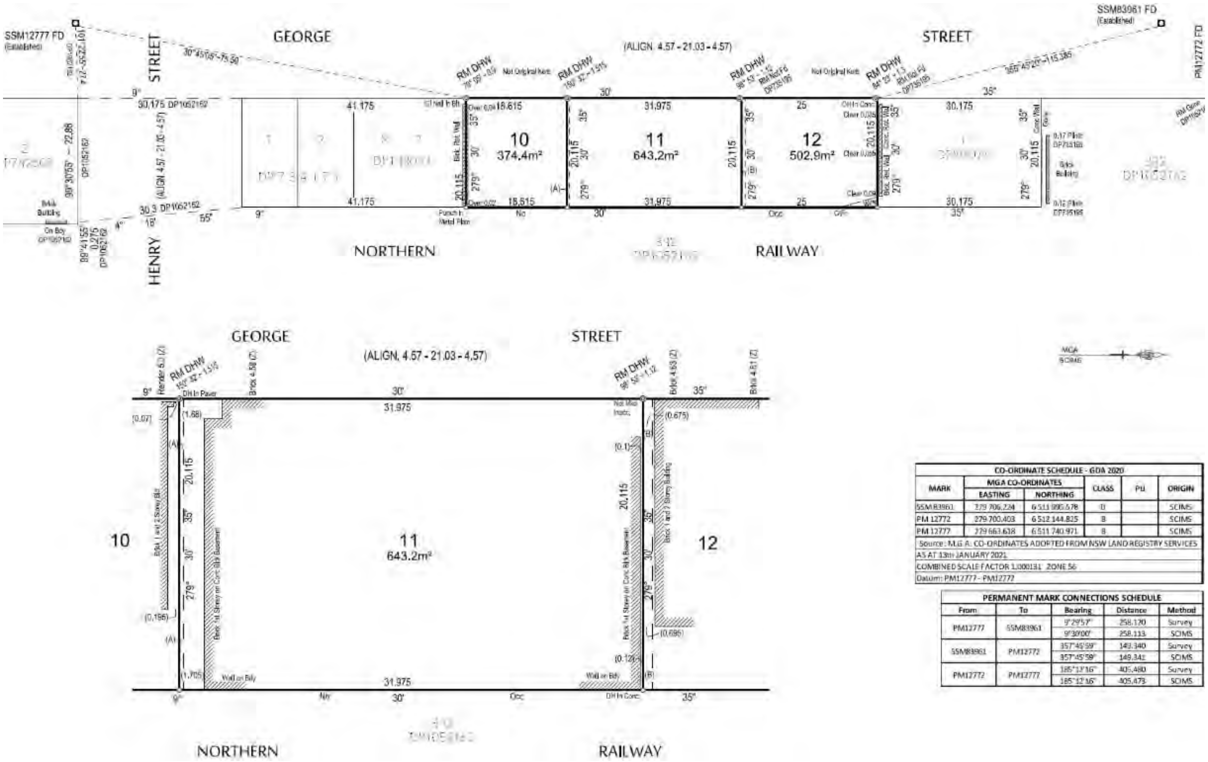

Figure 1: Case study – Quirindi.

3.3 Survey at Ingleburn

Figure 2 shows a survey at Ingleburn.

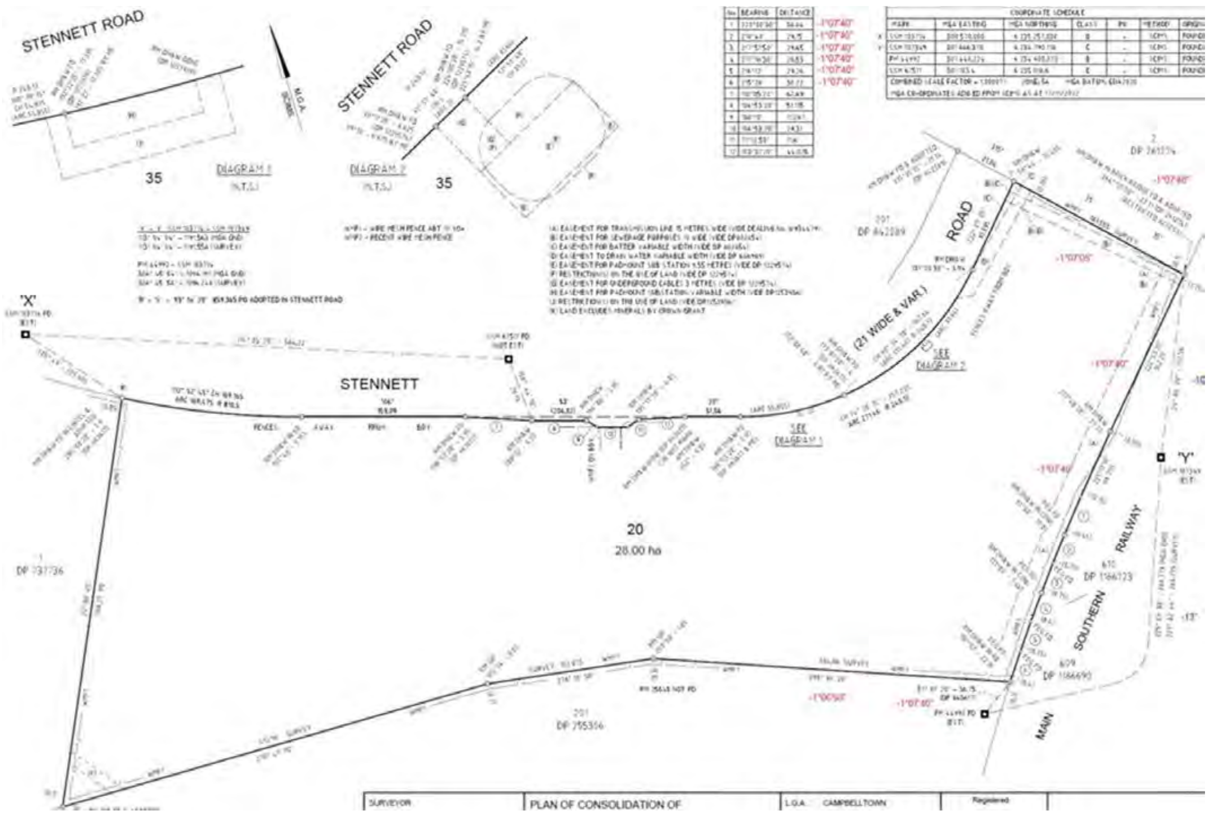

Figure 2: Case study – Ingleburn.

The following points are to note:

- Reference Marks (RMs) are found at each end of the railway boundary.
- There is a consistent azimuth difference to the previous plan, and the distances are close to per original.
- The surveyor submitted the plan for approval as they had previous experience with LRS.

4 CASE STUDIES OF PLANS THAT HAVE CONVERTED ARCS TO STRAIGHT LINE BOUNDARIES

4.1 Survey at Perthville

Figure 3 shows a subdivision survey of an old churchyard at Perthville. The following points are to note:

- The rail boundary is shown as two straight lines following the fence.
- The rail boundary is shown as an arc on the Working Plan (Figure 4) with centreline radius and side widths shown.
- The surveyor located the existing track, and a curved boundary relative to the centreline radius was adopted. The plan was re-submitted.

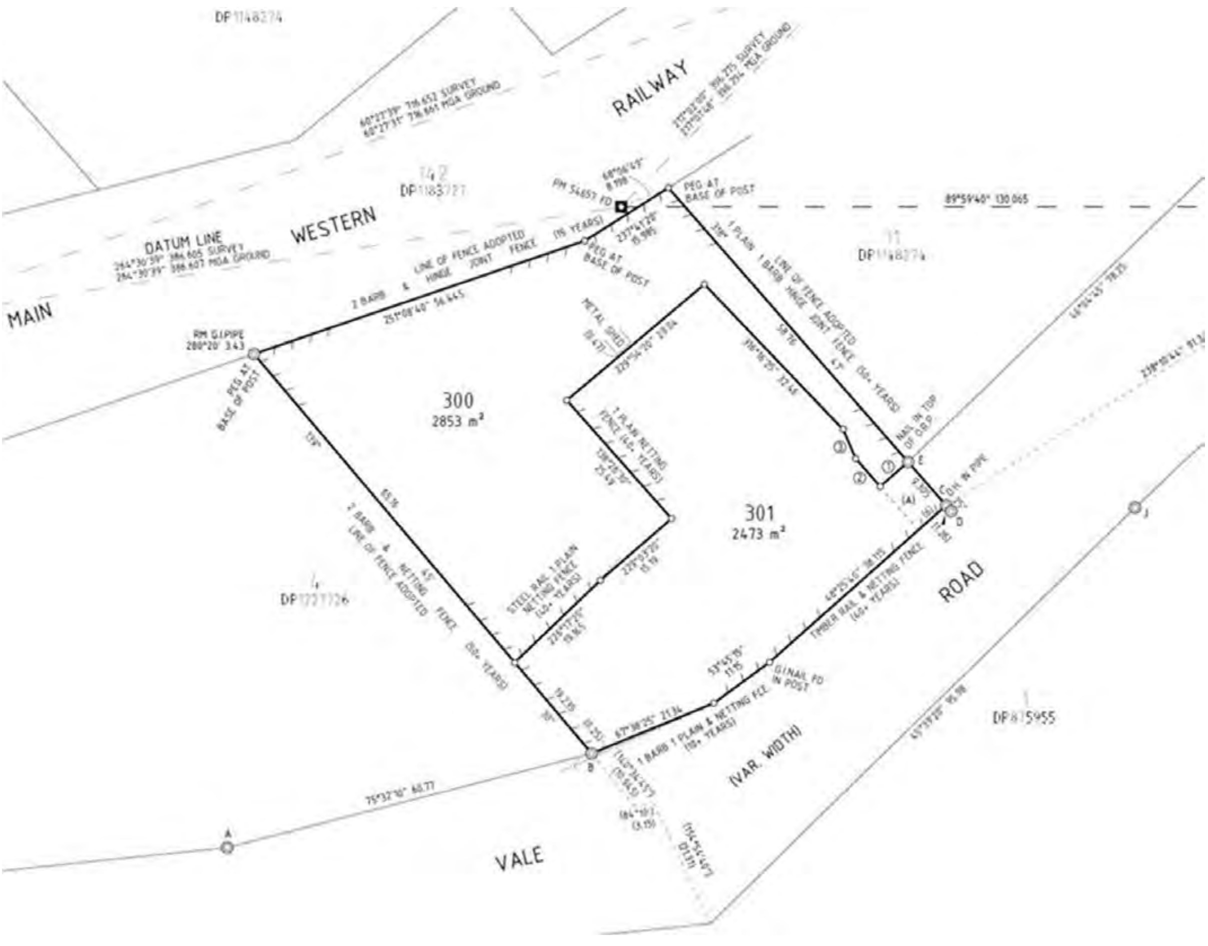

Figure 3: Case study – Perthville.

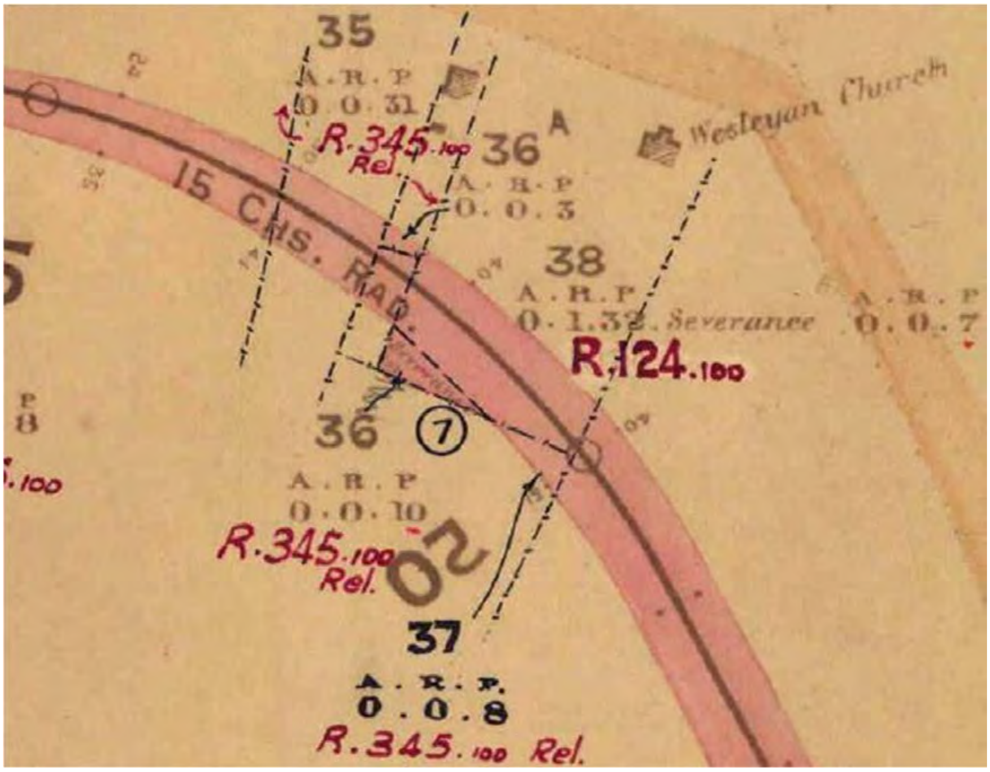

Figure 4: Case study – Perthville (Working Plan).

4.2 Survey at Dumaresque

Figure 5 shows a survey abutting a disused railway line, probably a bike trail, at Dumaresque.

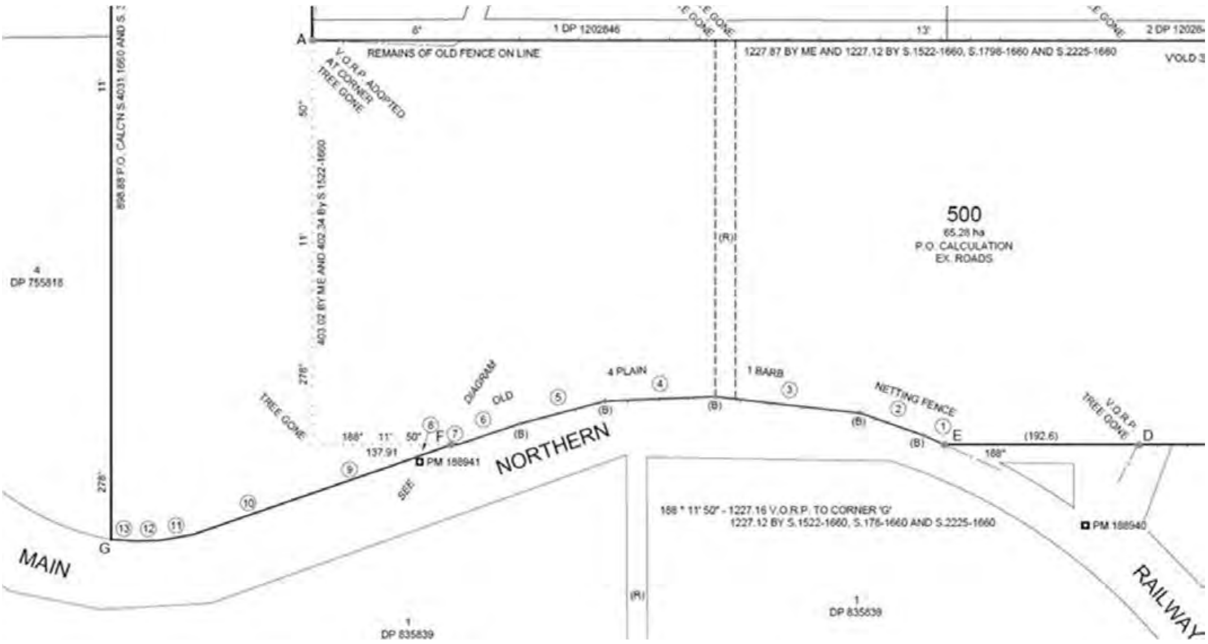

Figure 5: Case study – Dumaresque.

The following points are to note:

- The proposed rail boundary is shown as a series of straight lines, but a curve on the Working Plan (Figure 6).
- The corridor side widths are available from adjoining Working Plans and the distance from the centreline to the corner near S 1798 is shown on this plan (see Figure 6).
- The boundary adjoining lot 102 is defined by a portion plan.
- The parallel rail boundary was established by plotting the centreline using the available information, and the DP was amended.

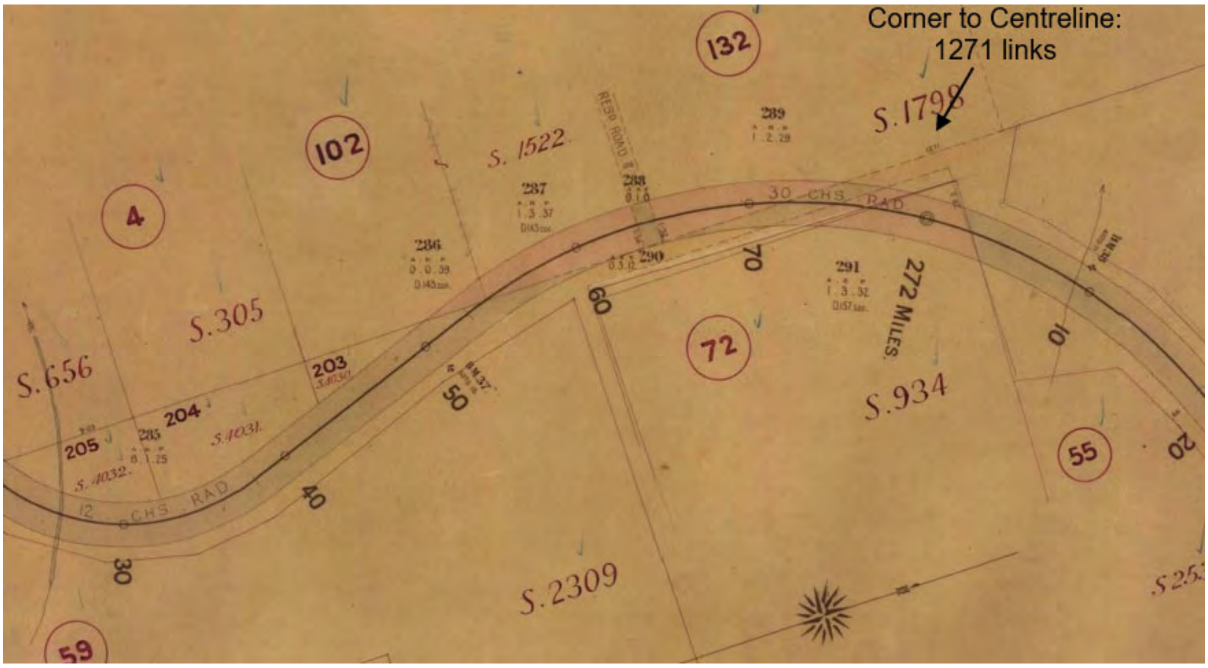

Figure 6: Case study – Dumaresque (Working Plan).

4.3 Considerations

Inconsistencies often exist in the definition of a railway boundary as shown on the diagrams on old certificates of title (usually a series of curves of specified arc lengths, chords and radii) and as defined in a new DP (usually a series of straight lines adopting the railway fence). The original curved boundaries of the railway were calculated at a set distance from the centreline of the track. However, due to subsequent reconstruction of the track since the date of original construction, the position of the original boundary may be lost.

Current (new?) LRS guidelines suggest adopting the railway fence where "doubt exists as to the position of a railway boundary". Previous advice, dating back to the 1990s, was that curved boundaries were to be maintained wherever possible, with details as per the Working Plans. This has been our mantra when reviewing railway boundaries since that time. Current procedure is to be maintained, "doubt" being a very subjective word.

5 CASE STUDY OF CONFUSED BOUNDARY RESOLUTION

A road closure plan at Millthorpe was submitted to TfNSW and the Country Rail Network (CRN). It was found that the surveyed boundary was significantly different to GIS / SIX Maps (DCS Spatial Services, 2023), which prompted questions to be raised (Figures 7 & 8).

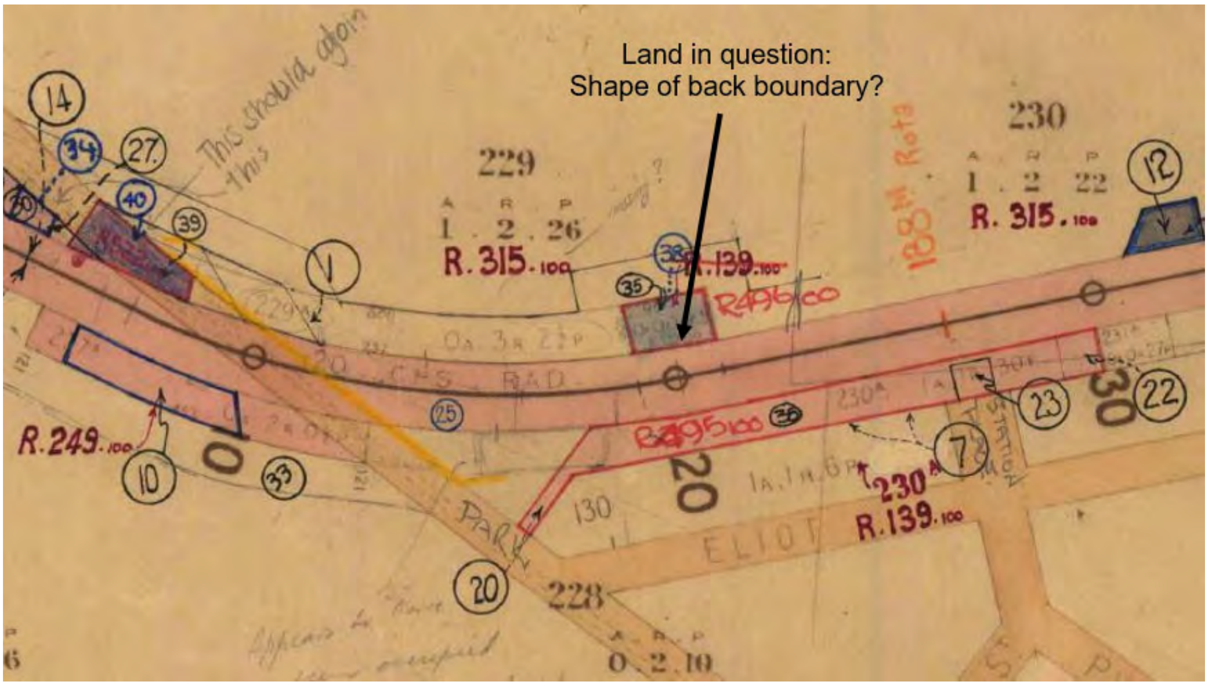

Figure 7: Case study – Millthorpe (Working Plan).

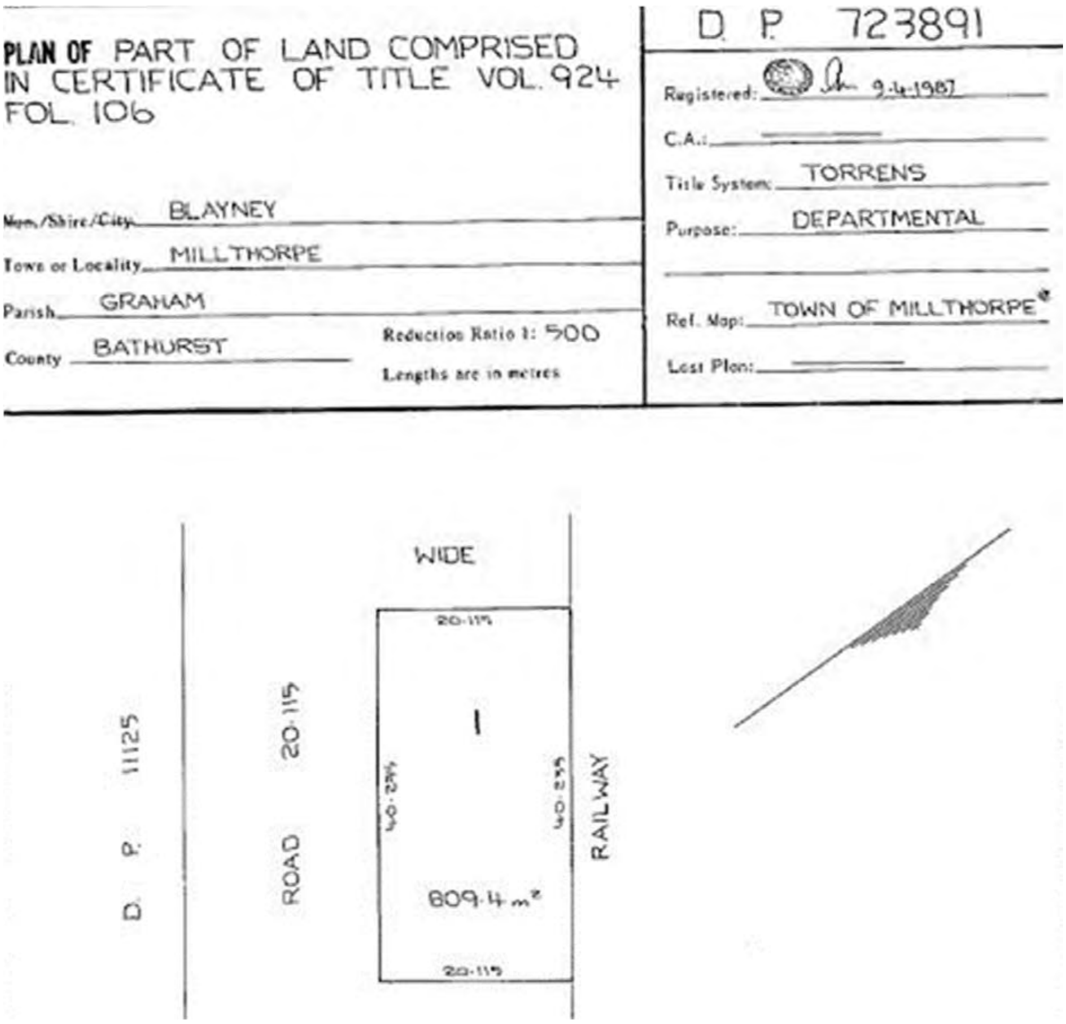

Figure 8: Case study – Millthorpe (Departmental Plan).

The following points are to note:

- The land shown on the departmental plan at time of sale indicates a 1-chain deep rectangle, while three sides are fixed by road widths (see Figure 8). A rectangular block results in a 3-metre step in the railway boundary but is close to occupations.
- There is no record of acquisition of the land. Was the intention to sell a rectangle or the land between the rail boundary (corners defined by road widths) and the road? After much discussion, the latter option was adopted (Figure 9).

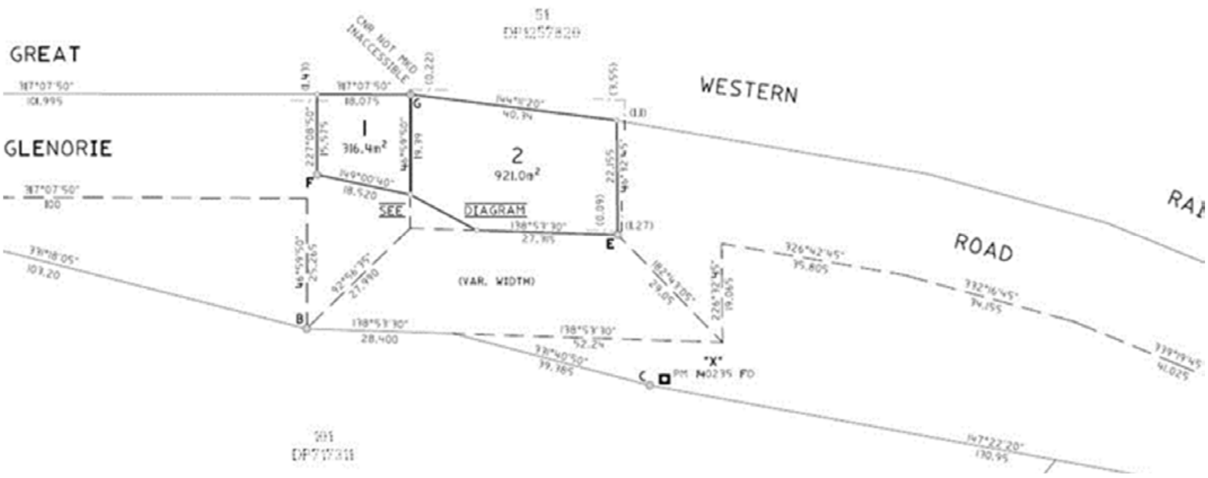

Figure 9: Case study – Millthorpe (lot 1 is the road to be closed).

6 CONCLUDING REMARKS

In an effort to reduce the number of rail boundary approval requests being returned to the surveyor for clarification or amendment, this paper has presented examples of the problems encountered and outlined the reasons for requisition.

The following two questions should be asked before submission:

1) Does your plan need to be submitted to TAHE for approval of a surveyed railway boundary? At this time, this is the easiest option.
2) Is there a tricky definition? Speak to someone from Property or a Sydney Trains surveyor. We have access to old records and understand Working Plans very well.

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Taming the BEAST: Establishing Street Intersection Corners

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ABSTRACT

At APAS2015, the first author presented a paper entitled 'Re-Markable Roads: When is a Street Fix Fixed?' In the conclusion, it was proposed to accumulate data at street intersections, including cadastral boundaries and markings by way of a scanning process. The idea was to create a simplified, abridged scan of the built environment at street intersections to house, hold and deliver thousands of points that are useable, stable and accurate enough to define or re-establish a street intersection. As envisaged in a point cloud, an image of the original scanned intersection can be uploaded into a controller, which can then identify, for survey definition or marking purposes, the previously established corners. The loss of actual survey marks at corners, such as pegs, drilled holes or reference marks, can be immediately overcome with reference to the point cloud data image. At City of Ryde, the survey team has investigated this approach, and this paper presents the initial findings. In order to be able to rely on scanned data for cadastral purposes, the scanning procedure must be reliable, repeatable and sub-centimetre accurate. We feel that this is now achievable.

KEYWORDS: *Intersection, road boundary, cadastre, laser scanning, reference points.*

1 INTRODUCTION

Decades after the first land grants in Ryde, which were among the first in the new colony, came the freehold subdivisions of these grants, which effectively changed Ryde from a rural community into a residential urban development. This was the decade of the 1880s, and at a time when modern survey accuracy was being achieved, many new roads were being created and boundary marking was beginning to standardise. However, it would be several more decades before reference marks were required to be placed and shown on plans creating new roads. Alignment posts were being placed along old existing roads in an attempt to rationalise their boundary locations (de Belin, 2014), and many of the early suburban subdivisions tied directly to alignment posts in aligned streets (Figure 1). Here, DP 7997 (1914) is bounded by Blaxlands Road (now Blaxland Road), which has been defined from seven stone alignment posts found. With the arrival of the Local Government Act in 1919 came the requirement to mark newly created streets with solid reference marks, a requirement which has continued to this day. This was 40 years after 1880! In that intervening period, original pegs were removed for first fencing purposes, which led to the situation where the surveyor arrived on site to carry out a survey, only to find no corner marks for a starting point or confirmation of boundary.

Figure 1: DP 7997 showing alignment definition of Blaxland Road, Eastwood (1914).

DP 7997 created two new streets: Denistone Road and Dalton Avenue. No reference marks were placed, nor required to be placed, as the survey was prior to 1919. What was any following surveyor to do when it came to defining these two streets? A further complication was that many compiled plans of subdivision, which did not require marking, were initiated in this period, based on the initial subdivision and creating a shuffling of boundaries (such as three original lots into five). The surveyor looked to occupations for support and came up with a best estimate for the correct street boundary. This Best Estimate Asserting Survey Truth (BEAST) has hampered, hindered or helped cadastral surveyors in determining street boundaries ever since.

At APAS2015, a paper was presented entitled ‘Re-markable roads: When is a street fix fixed?’ (de Belin, 2015). In its conclusion, it was proposed to accumulate data at street intersections, including cadastral boundaries, marks and buildings by way of a scanning process. The idea was to create a simplified, abridged scan of the street intersection to house, hold and deliver thousands of points that are useable, stable and accurate enough to define or re-establish a street intersection. This data could later be useful in the re-establishment of a street intersection, especially if no original survey marks exist on site.

2 FEEDING THE BEAST

To show how street definition can change over time, let us discuss two examples from the multitudes which exist within the City of Ryde.

2.1 Pittwater Road

Pittwater Road at North Ryde was created in 1882 as a main road, 150 links wide, and extended across Magdala Road (Figure 2). In 1884, Pittwater Road was extended northwards as a straight-line continuation through vacant Crown land (Figure 3). In 1887, this vacant Crown land on either side of Pittwater Road was subdivided into small portions, with Pittwater Road maintained as a straight line (Figure 4). Pittwater Road was aligned in 1885, although only a tracing of the alignment plan remains, catalogued CP 23.2113 (1885).

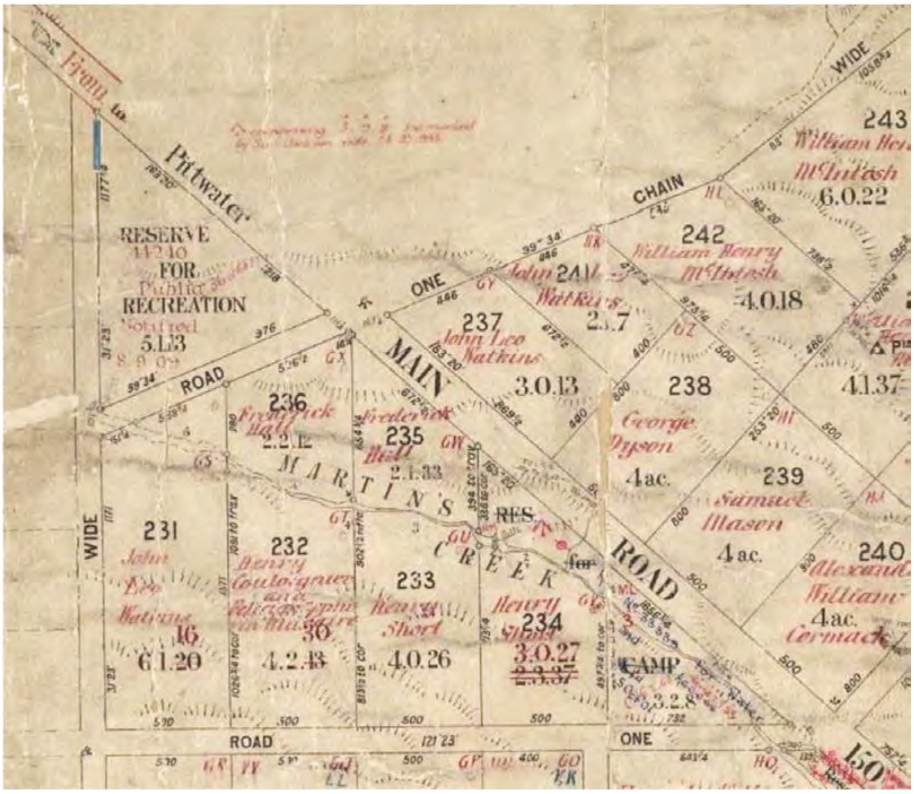


Figure 2: CP 386.2030 showing the creation of Pittwater Road (1882).

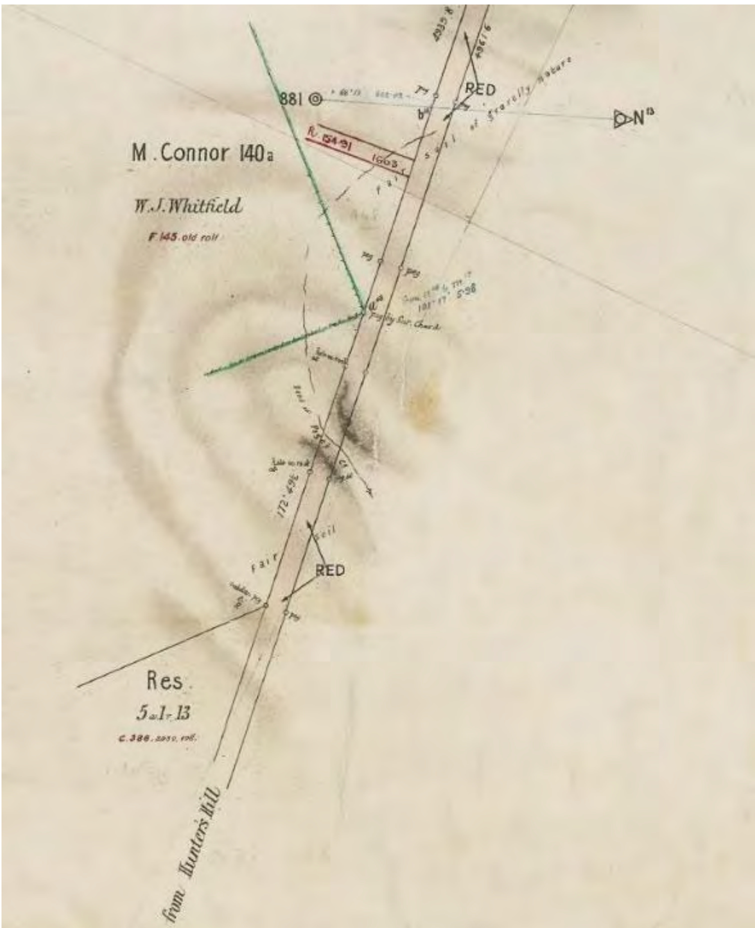


Figure 3: CP 2713.1603 showing the north extension of Pittwater Road in a straight line (1884).

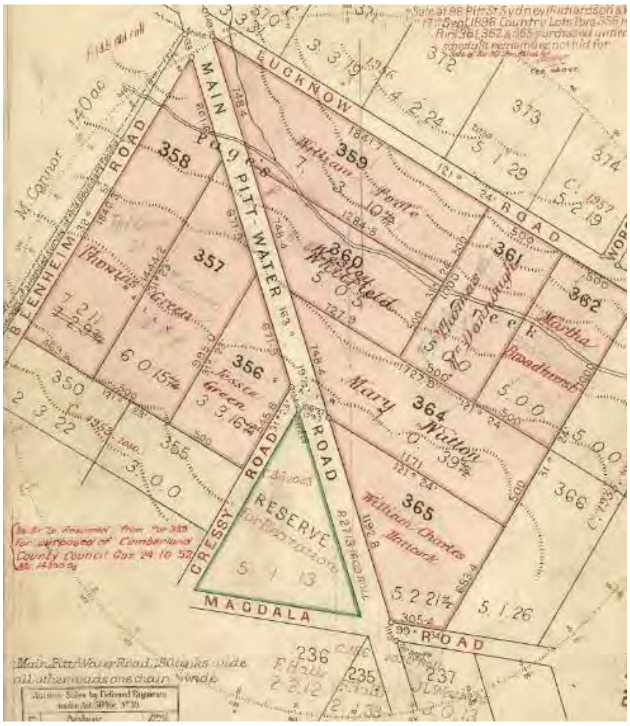


Figure 4: CP 1954.2030 showing Pittwater Road as one straight line (1887).

Pittwater Road, south of Magdala Road, can still today be fixed from surviving big stone alignment posts (de Belin, 2014) and surviving original corner rock marks from 1882 (de Belin, 2017). Pittwater Road, north of Magdala Road, is where the street fix starts to come adrift. Table 1 shows the timeline of survey activity since 1882.

Table 1: Timeline of survey activity in Pittwater Road.

Plan	Date	Survey or Compiled	Reference to Prior Survey
CP 386.2030	1882	Survey	First Portions
CP 2713.1603	1884	Survey	Road
CP 23.2113	1885	Survey	Alignment
CP 1954.2030	1887	Survey	First Portions
DP 8095	1911	Survey	CP 1954.2030
DP 317762	1927	Survey	DP 8095
DP 19636	1941	Survey	CP 386.2030
DP 25524	1953	Survey	CP 1954.2030
DP 27333	1956	Survey	CP 1954.2030
DP 402144	1957	Survey	DP 8095
DP 28139	1957	Survey	CP 1954.2030
DP 404958	1957	Compiled	DP 8095
DP 418768	1960	Survey	DP 8095
DP 879421	1998	Survey	DP 7997 & DP 835760
DP 882160	1998	Survey	DP 8095 & DP 404958 (C)
DP 1016621	2000	Survey	DP 28139
DP 1039302	2001	Survey	DP 8095
DP 1109818	2006	Survey	DP 8095

Fast forward 70 years to 1957. DP 402144 (1957) finds a multitude of alignment posts, fixes Pittwater Road straight and places two reference marks (GI pipe and bolt). DP 418768 (1960) finds the bolt and continues a straight street-line to pegs found over 250 m to the north, then places a reference mark GI pipe midway. Forty years later, DP 879421 (1998) adopts this GI pipe, then continues the straight line for almost 500 m to the north (Figure 5).

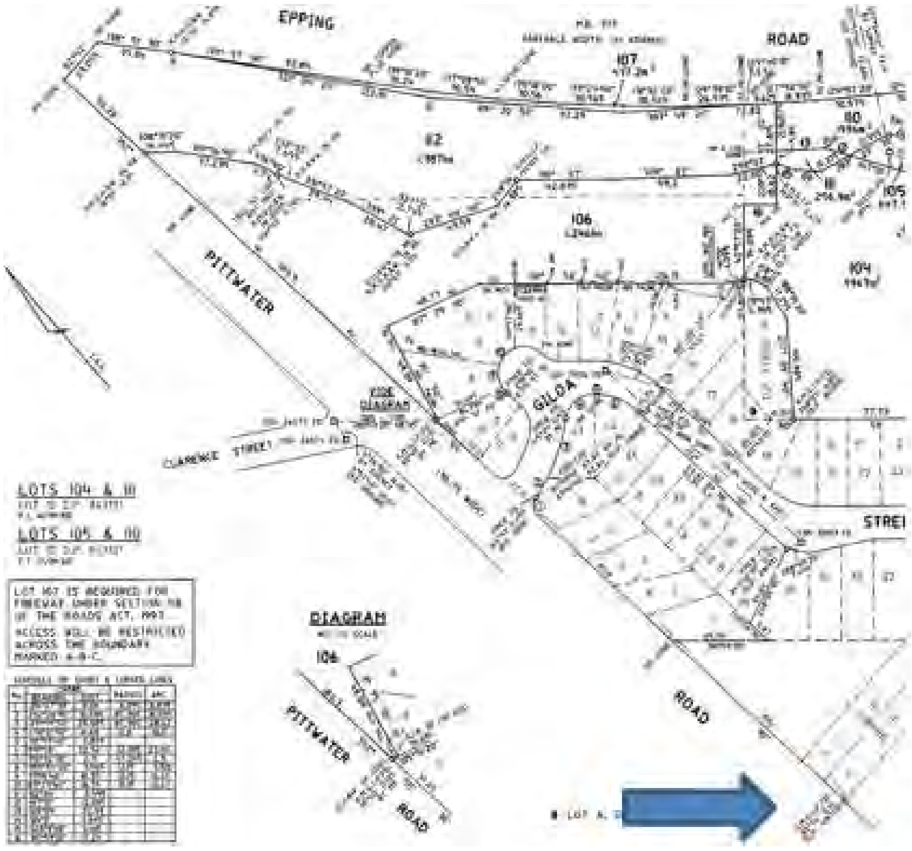


Figure 5: DP 879421 showing Pittwater Road as one straight line (1998).

Then, in 2000, the BEAST arrives! DP 1016621 (2000) creates a drainage easement, and in showing and confirming that enough land is available between the start of the drainage easement and Pittwater Road, the surveyor shows three connecting lines between five reference marks as found in Pittwater Road (Figure 6), which effectively indicates that Pittwater Road now has bends.

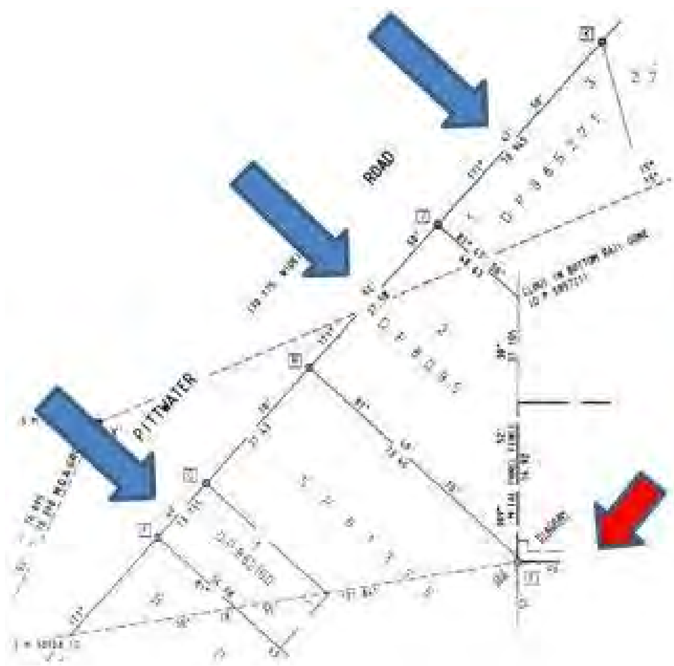


Figure 6: DP 1016621 showing Pittwater Road having bends between adjacent reference marks (2000).

The same surveyor returns in 2001 to subdivide the property, which had the benefit of the drainage easement (Figure 7). This DP 10319302 (2001) shows identical bends in the fix of Pittwater Road.

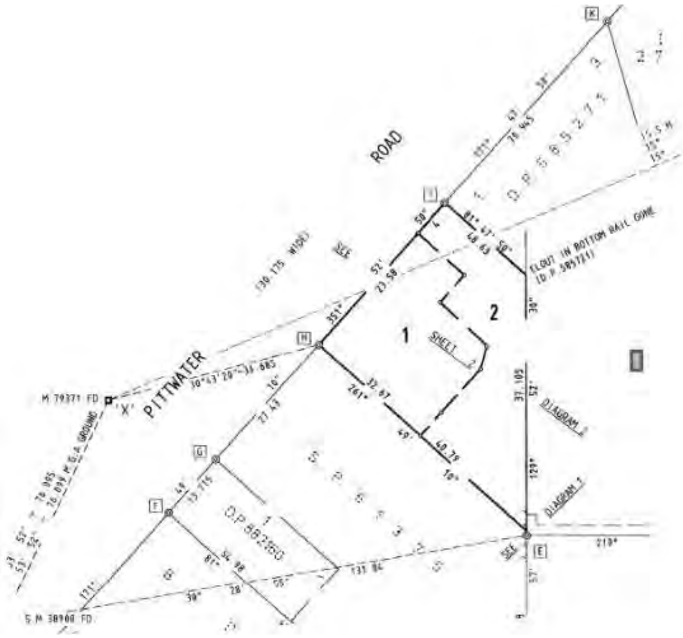


Figure 7: DP 1039302 showing Pittwater Road with the same bends (2001).

Along comes a different surveyor in 2006 who attempts to define the Pittwater Road boundary in a straight line. His DP 1109818 (2006) is requisitioned by Land and Property Information (now DCS Spatial Services) (Figure 8) to re-instate the three bends shown previously in DP 1039302 (2001).

Figure 8: DP 1109818 showing Pittwater Road maintaining the same bends (2006).

A full investigation by the City of Ryde survey team reveals that the original straight-line street fix of Pittwater Road can be validated over its entire length of 1,000 m, with both sides parallel and 30.175 m (150 links) apart. More about this example later.

2.2 Denistone Road & Dalton Avenue

Denistone Road and Dalton Avenue, at Eastwood, were created in 1914 as part of residential subdivision DP 7997 (see Figure 1). The definition of Denistone Road today puts the street in a different position, i.e. about 150 mm south from where it was placed in 1914. This has obvious ramifications on a lot's depth and rear boundary. The Cadastral Records Enquiry (CRE) shows the current lot subdivision plans over part of DP 7997 (Figure 9).

Figure 9: Cadastral Records Enquiry map showing the current lot subdivision plans over part of DP 7997 (2023).

Table 2 shows the timeline of survey activity since 1914. The first plan of survey was DP 12911 (1923), which adopted a line of pegs found in Denistone Road and a line of pegs found in Ryedale Road. Street angles and lot dimensions completely agreed with DP 7997. The next survey plan, DP 15864 (1927), adopted the pegs placed by DP 12911 in 1923. It is 1940 before the next survey plan appears (Figure 10) and some interesting points are worth noting.

Table 2: Timeline of survey activity in Denistone Road. Note that the flurry of survey activity since 1993 began 80 years after the first subdivision in 1914.

Plan	Date	Survey or Compiled	Reference to Prior Survey
DP 7997	1914	Survey	First Subdivision
DP 952366	1916	Compiled	DP 7997
DP 167865	1921	Compiled	DP 7997
DP 169594	1921	Compiled	DP 7997
DP 12911	1923	Survey	DP 7997
DP 312937	1925	Compiled	DP 7997
DP 15864	1927	Survey	DP 12911
DP 333097	1936	Compiled	DP 7997
DP 336713	1938	Compiled	DP 7997
DP 343691	1940	Survey	DP 15864
DP 19500	1940	Survey	DP 7997 & DP 15864
DP 508494	1962	Compiled	DP 312937 (C)
DP 306621	1963	Compiled	DP 7997
DP 532938	1968	Compiled	DP 7997
DP 537517	1969	Compiled	DP 7997
DP 609259	1980	Compiled	DP 7997
DP 703989	1983	Compiled	DP 7997
DP 717176	1984	Compiled	DP 7997

Plan	Date	Survey or Compiled	Reference to Prior Survey
DP 724091	1987	Compiled	DP 7997
DP 773924	1988	Compiled	DP 7997 & DP 724091 (C)
DP 835760	1993	Survey	DP 7997
DP 837289	1993	Survey	DP 7997 & DP 835760
DP 837290	1993	Survey	DP 7997 & DP 835760
DP 854286	1995	Survey	DP 306621 (C) & DP 7997
DP 869648	1995	Survey	DP 7997
DP 876250	1996	Survey	DP 7997
DP 881658	1997	Survey	DP 7997
Urban Cadastral Project	2022	Survey	DP 7997

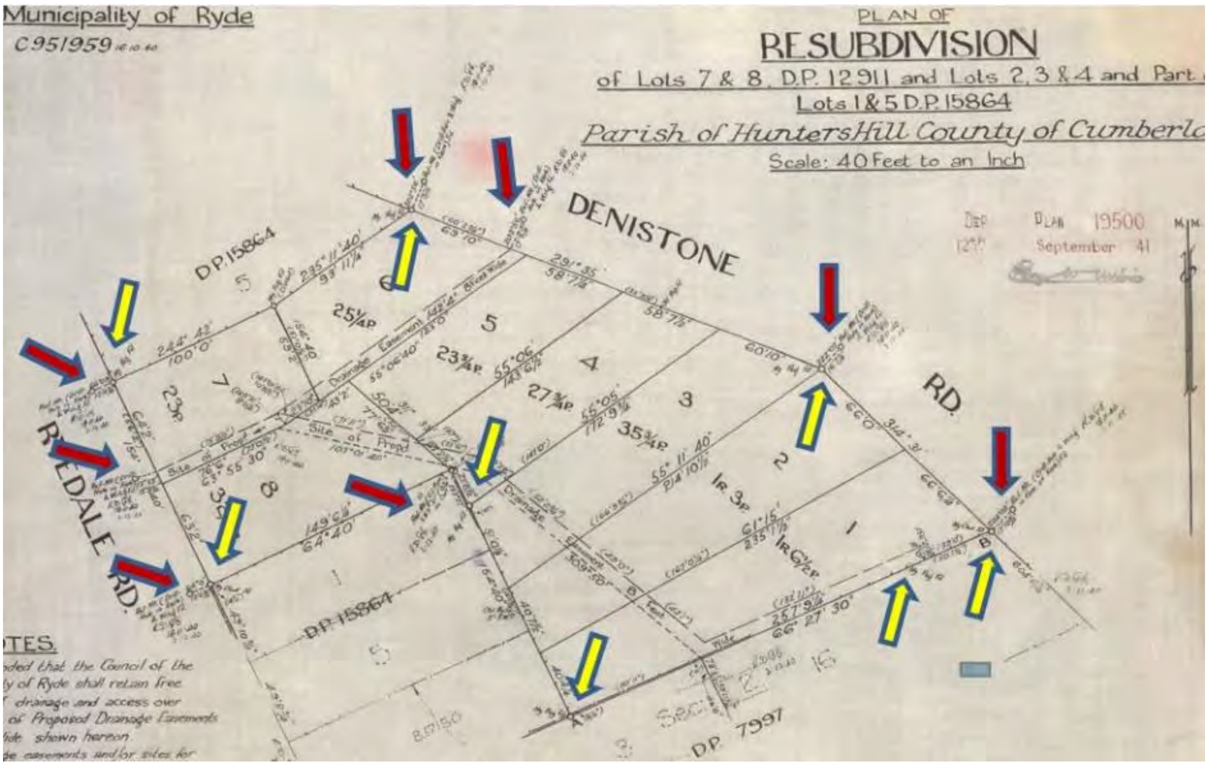


Figure 10: DP 19500 showing at corners “my mark found” and “reference mark found” (1940).

Additions to DP 19500 indicate two rounds of survey requisitions. Adjoining side occupations have been added south along Denistone Road and Ryedale Road, a line in the surveyor’s certificate in regard to the placing of survey reference marks has been struck out (not shown in Figure 10) and each reference mark found shows the evidence of two rounds of requisition (Figure 11).

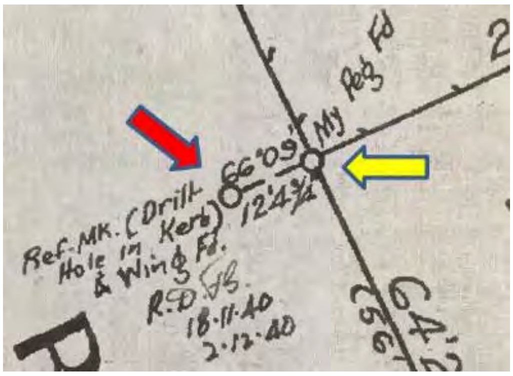
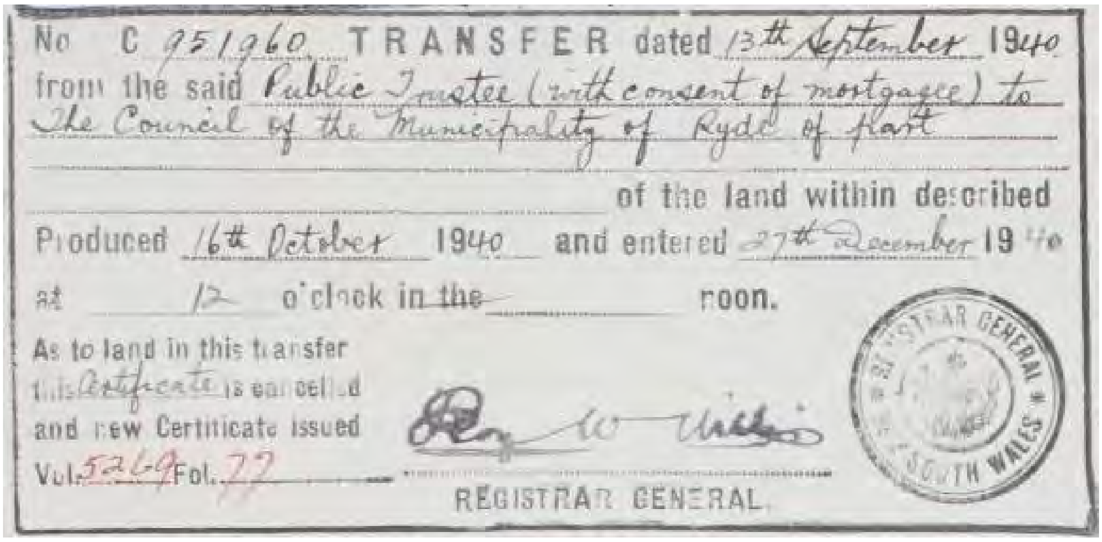


Figure 11: Detail from DP 19500 showing marks found and evidence of requisitions (1940).

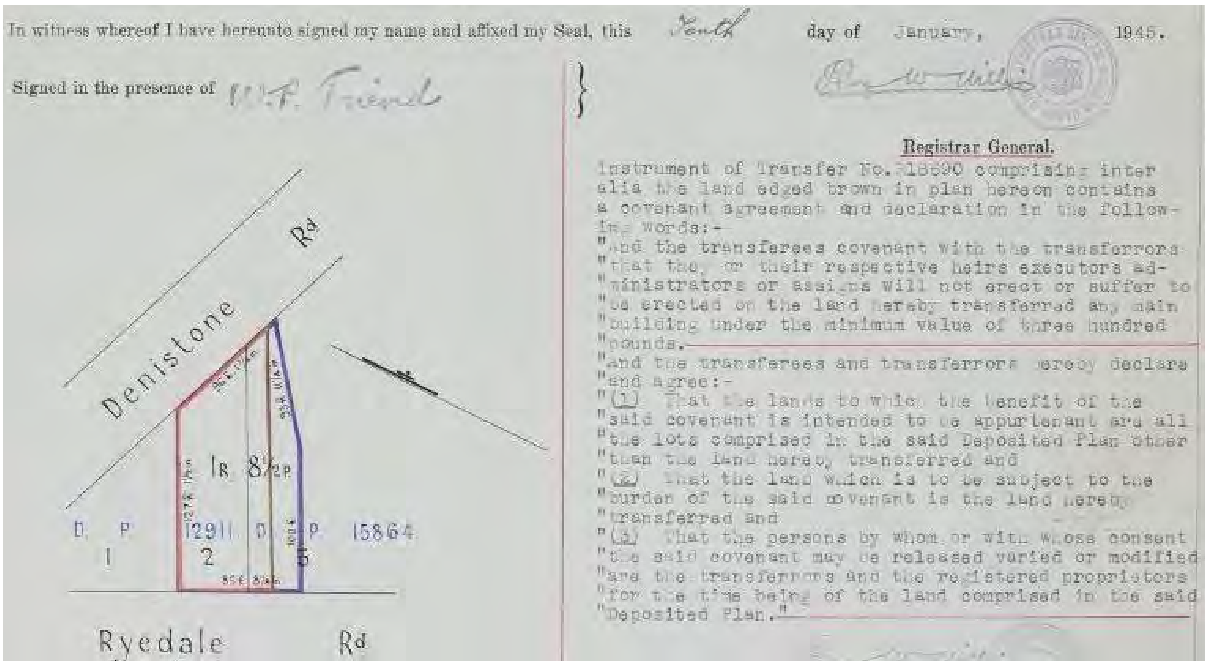
There were no reference marks placed by this survey. Obviously, to be found, the reference marks had to have been placed in an prior survey. But which survey? The CRE indicates nothing! However, a title search reveals a transfer dealing C951960 (1940) on Certificate of Title Volume 4213 Folio 2 (Figure 12), which contains a survey plan carried out by the same surveyor and showing the seven reference marks found by DP 19500 (1940).



No C 951960 TRANSFER dated 13th September 1940
from the said Public Trustee (with consent of mortgagee) to
The Council of the Municipality of Ryde of part
of the land within described
Produced 16th October 1940 and entered 27th December 1940
at 12 o'clock in the noon.
As to land in this transfer
this Certificate is cancelled
and new Certificate issued
Vol. 5269 Fol. 77
REGISTRAR GENERAL

Figure 12: Transfer dealing C951960 noted on Certificate of Title Volume 4213 Folio 2 (1940).

The land comprised in Certificate of Title Volume 5269 Folio 77 is all the land in DP 15864 (1927) minus that land being part of lot 5 and edged in blue (Figure 13), as shown on Certificate of Title Volume 5467 Folio 203 (1945).



In witness whereof I have hereunto signed my name and affixed my Seal, this Tenth day of January, 1945.

Signed in the presence of W.F. Friend

Registrar General.

Instrument of Transfer No. 18690 comprising inter alia the land edged brown in plan hereon contains a covenant agreement and declaration in the following words:-
"And the transferees covenant with the transferrors "that they or their respective heirs executors administrators or assigns will not erect or suffer to "be erected on the land hereby transferred any main "building under the minimum value of three hundred "pounds.
"And the transferees and transferrors hereby declare "and agree:-
"(1) That the lands to which the benefit of the "said covenant is intended to be appurtenant are all "the lots comprised in the said Deposited Plan other "than the land hereby transferred and
"(2) That the land which is to be subject to the "burden of the said covenant is the land hereby "transferred and
"(3) That the persons by whom or with whose consent "the said covenant may be released varied or modified "are the transferrors and the registered proprietors "for the time being of the land comprised in the said "Deposited Plan."

Figure 13: Title diagram in Volume 5467 Folio 203 showing result of transfer shown in Figure 12 (1945).

The survey plan attached to dealing C951960 is now catalogued as DP 343691 (1940). So, there were four plans of survey plus 15 compiled plans in the first 80 years after DP 7997. All reference marks from DP 343691 (1940), and as found in DP 19500 (1940), are now long gone.

In 1993, there was a modern plan of survey defining Denistone Road, which found recent pegs and adopted street fencing occupations at the bend by balancing and splitting the difference (Figure 14).

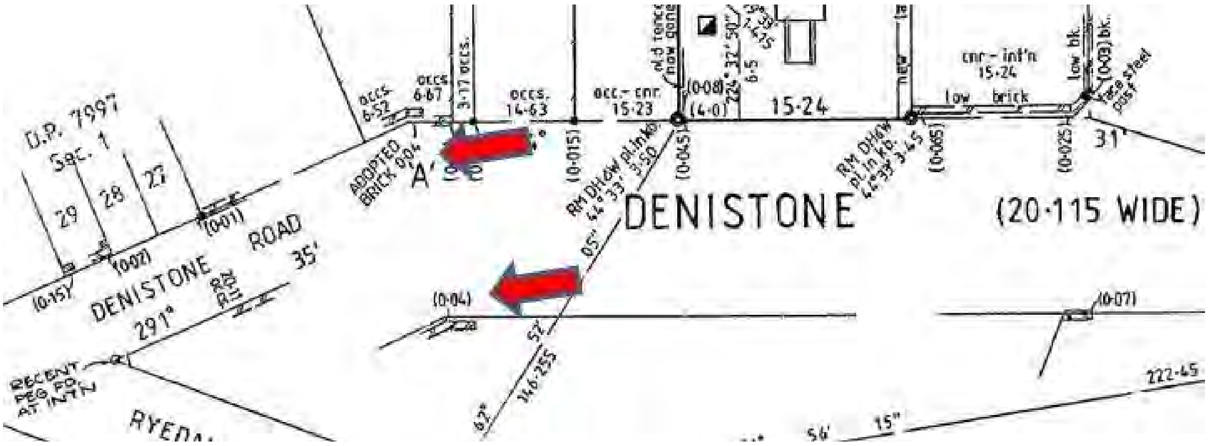


Figure 14: DP 854286 showing the bend in Denistone Road defined by adopting occupations (1995).

This plan of survey showed fencing occupations north towards Blaxland Road (Figure 15) suggestive of a northerly shift.

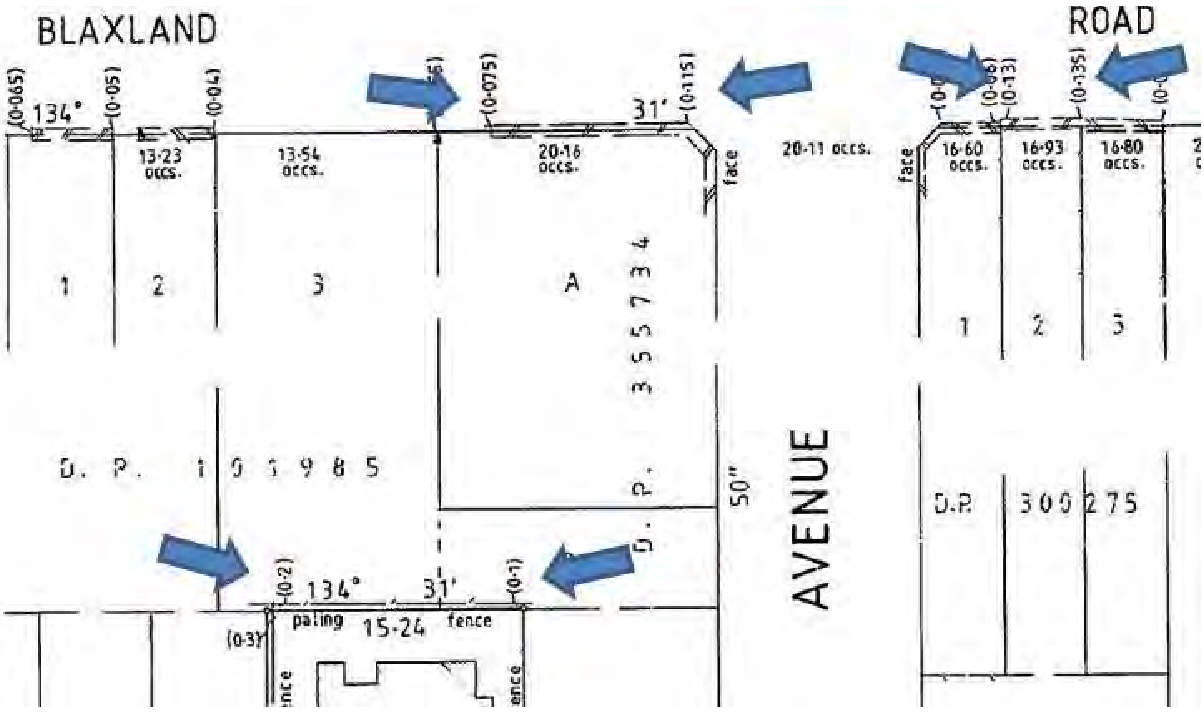


Figure 15: DP 854286 showing occupations northwards to Blaxland Road (1995).

DP 881658 (1997) adopts the same fix of Denistone Road as DP 854286 (1995) and shows some fencing occupations north of the Denistone Road boundary (Figure 16). This DP 881658 (1997) also shows excesses of up to 150 mm between Denistone Road and the definition of Blaxland Road, where an iron alignment post was found, in place of the original stone alignment post.

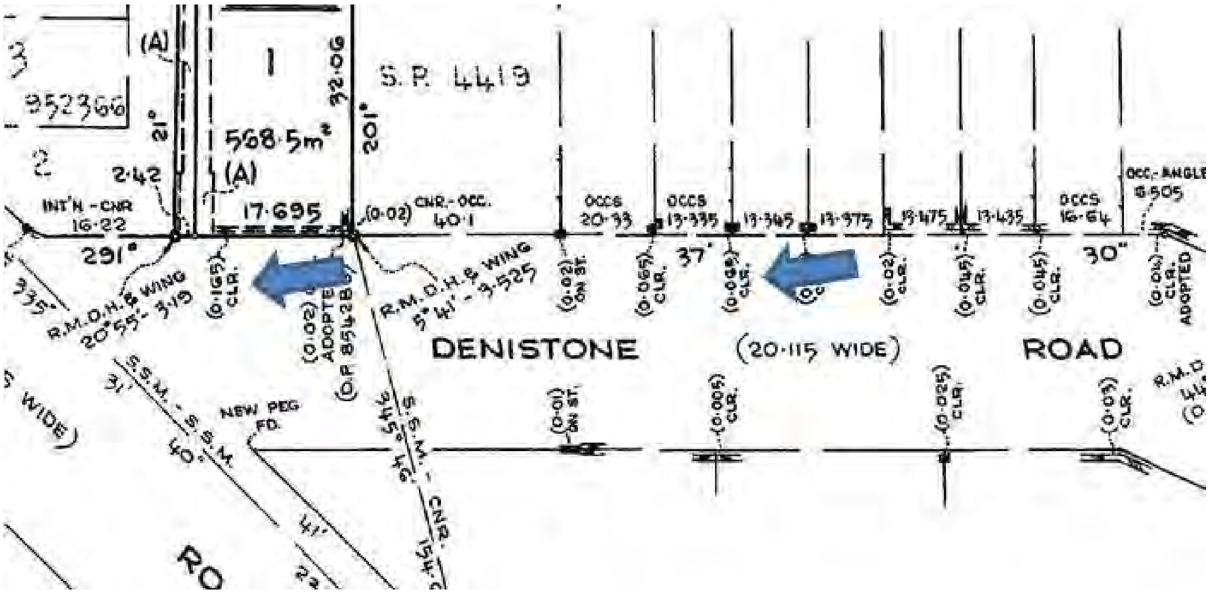


Figure 16: DP 881658 showing same fix of Denistone Road as DP 854286 from 1995 (1997).

A Board of Surveying and Spatial Information (BOSSI) urban cadastral project (2022) re-constructed the old alignment of Blaxland Road (Figures 17 & 18) as it was in DP 7997 (1914), by adopting connections from found reference marks (de Belin, 2018) that were placed at a time when some of the stone alignment posts were still in existence and in position, around 1960. The resultant fix of Blaxland Road was able to maintain original angles between kerb lines with no more than 20 mm difference in distances between the bends. DP 7997 (1914) was then laid out in accordance with original dimensions from the aligned Blaxland Road because the subdivision occurred after the alignment survey. More about this example later.

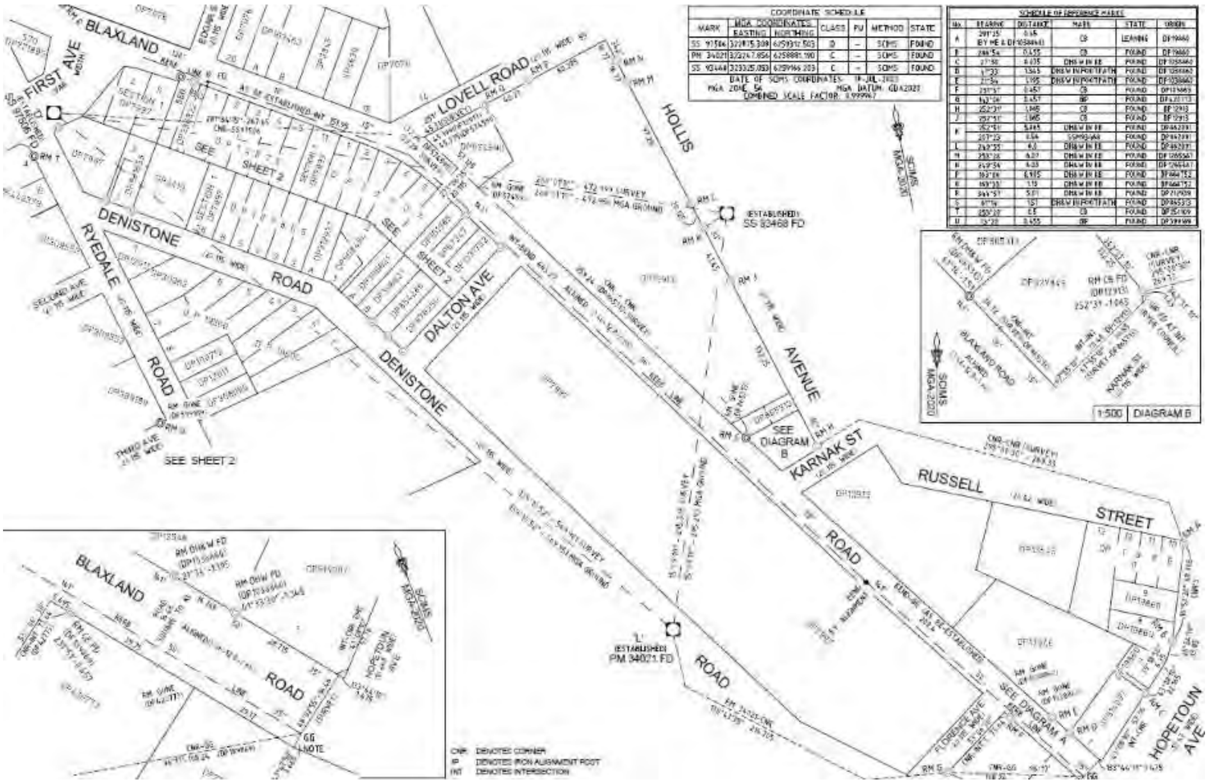


Figure 17: Urban cadastral project showing definition of Blaxland Road as per original (2022).

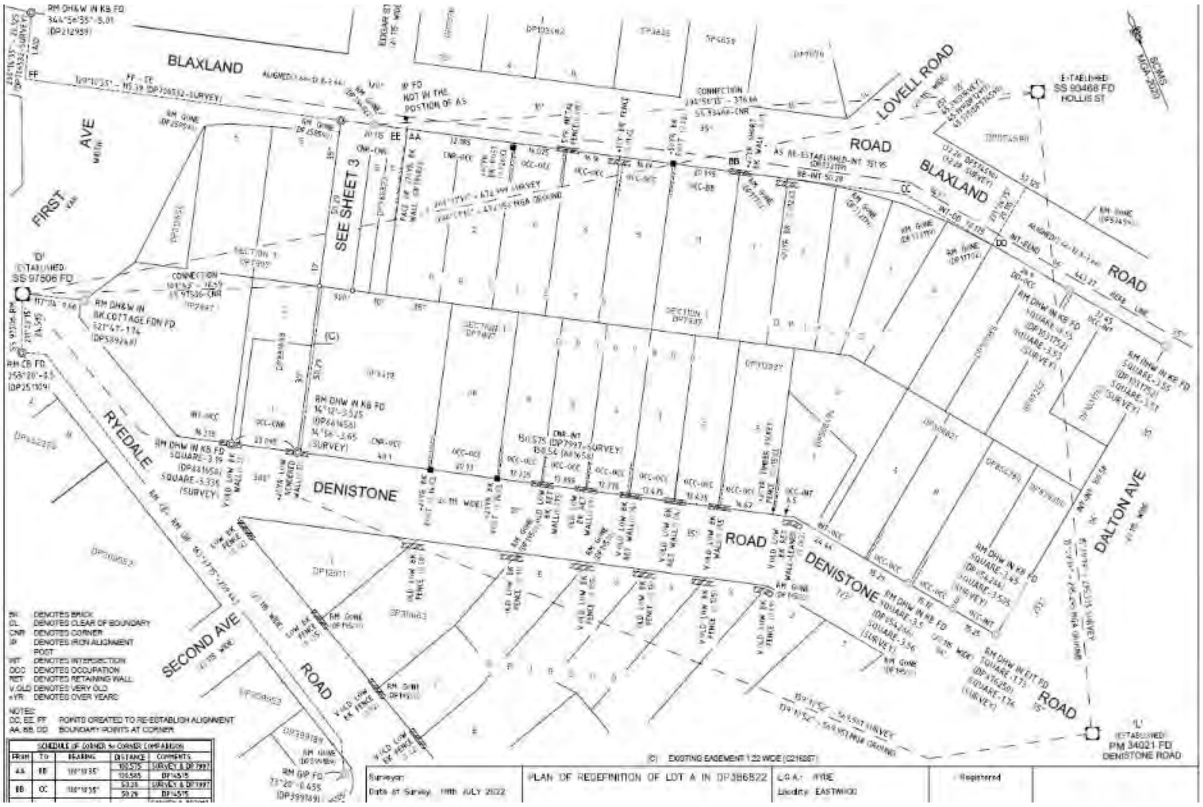


Figure 18: Urban cadastral project showing extents of DP 7997 maintained as per original (2022).

3 TRACKING THE BEAST

Council owns the land, which contains the road reservation after the creation of a new street. Streets are created parallel with a nominal width (Figure 19).

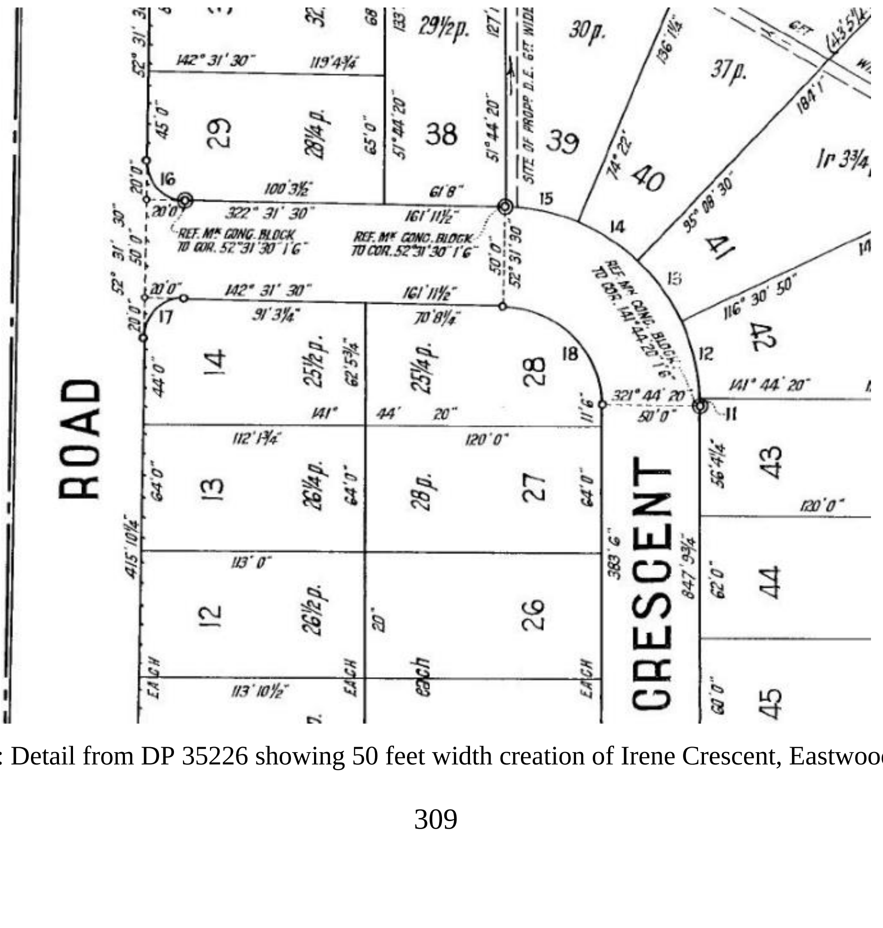


Figure 19: Detail from DP 35226 showing 50 feet width creation of Irene Crescent, Eastwood (1948).

Irene Crescent in Eastwood is reference marked by concrete blocks on one side of the street only. Similarly, Mawarra Crescent in Marsfield is reference marked by pairs of drill hole and wing in kerb on one side of the street only (Figure 20).

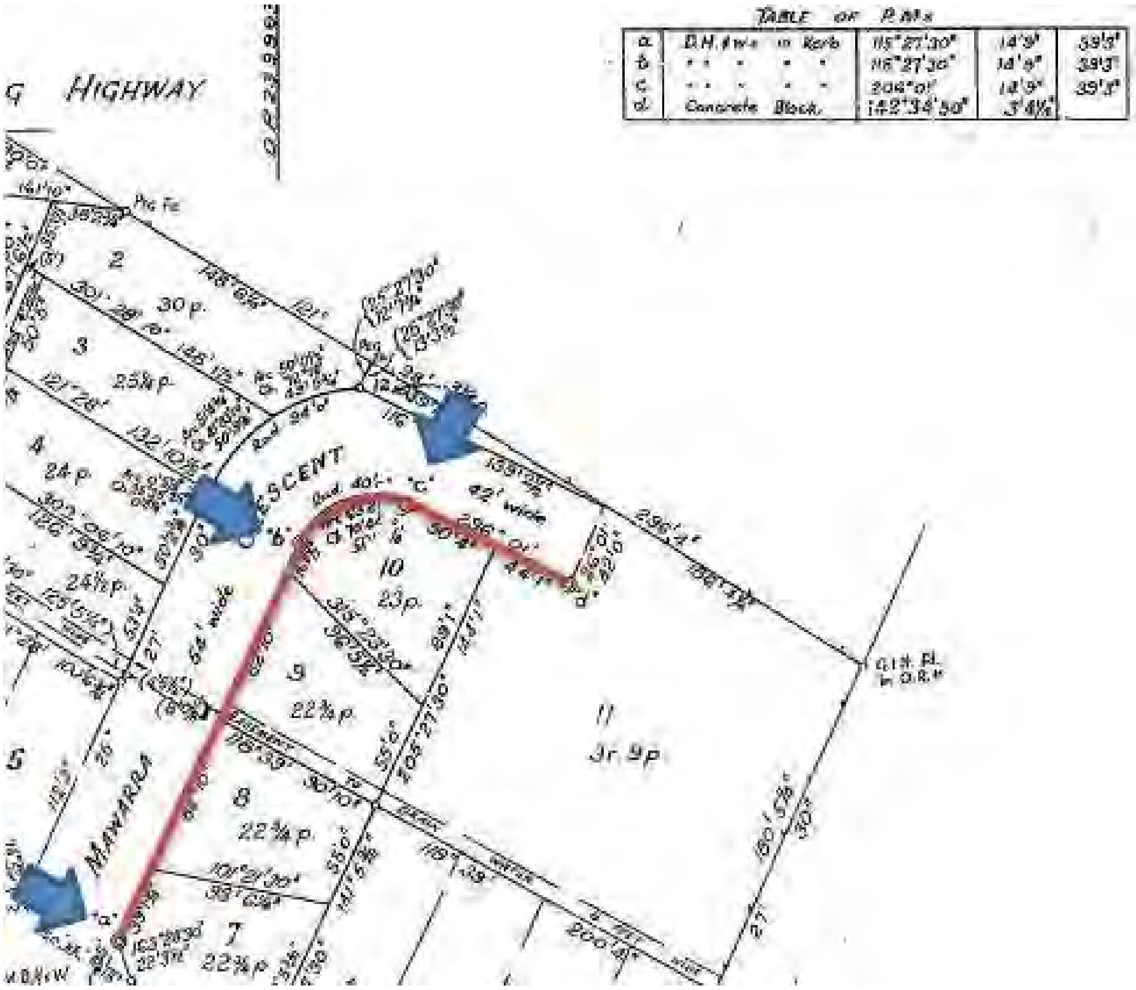


Figure 20: Detail from DP 239963 showing creation of Mawarra Crescent, Marsfield (1970).

Notice that only one side boundary of the created street is tied to reference marks. Therefore, any redefinition of the street requires only the one side of the street to be fixed, then the other side falls in parallel at nominated width. Exclusive of road widening and partial road closure, there is no reason for streets to become variable width!

In saying that, a point of interest is that two streets in the City of Ryde were actually created with a variable width rather than having variability thrust upon them at a later date when the street fix became too difficult or found reference marks suggested a deviation.

Frederick Street in Ryde was created in 1916 abutting the parcel boundary, which contained four bends (Figure 21), so one side of the new Frederick Street contained bends while the opposite side was one straight line.

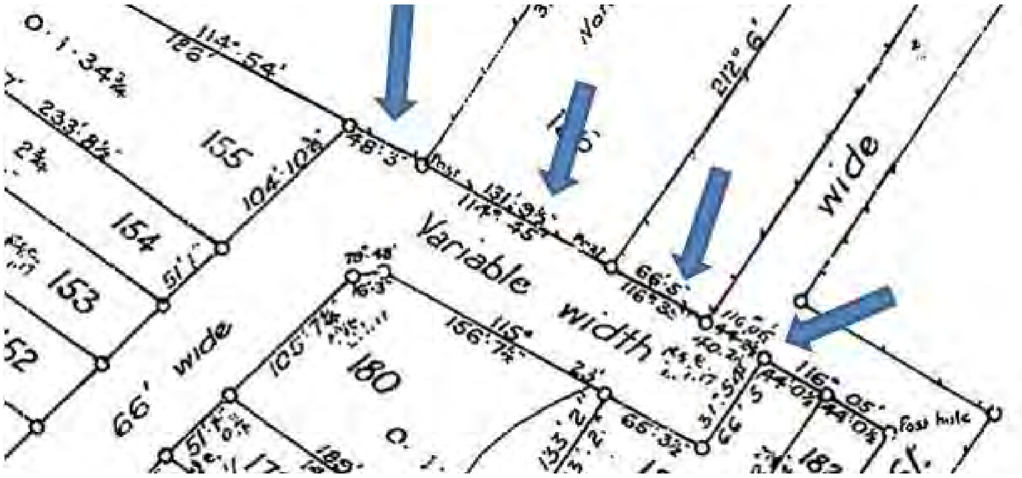


Figure 21: Detail from DP 8721 showing variable width creation of Frederick Street, Ryde (1916).

Goodwin Road at West Ryde was essentially a strip of land between two very first grants. DP 2085 (1887) adopted a straight fenced line as the limitation of its title and as the boundary line between itself and the 146-acre parcel to the north, intimating that this fence formed one side of a road (Figure 22).

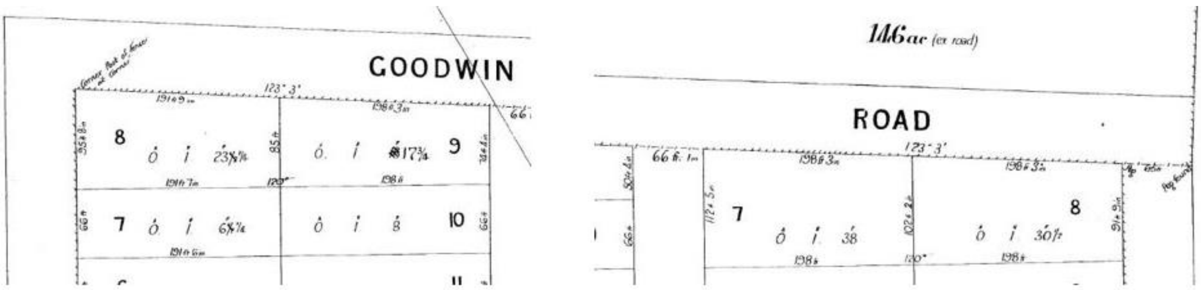


Figure 22: DP 2085 showing definition of one side of Goodwin Road, West Ryde (1887).

Later subdivision on the north also defined Goodwin Road by fencing occupations, with the result that the road boundary on the north has two bends and the street has a width which varies from 66 feet at one end to 47 feet at the other (Figure 23).

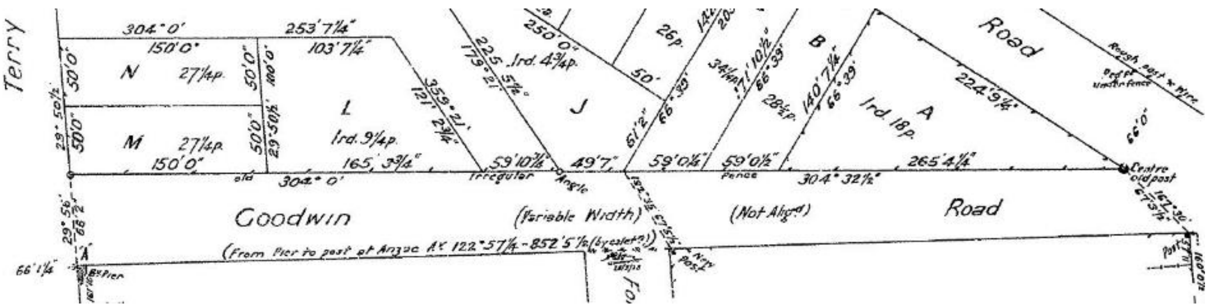


Figure 23: DP 15547 showing variable width definition of Goodwin Road, West Ryde (1928).

Clause 33 of the Surveying and Spatial Information Regulation 2017 (NSW Legislation, 2023) states:

> 33 Procedure if monuments of original survey missing
>
> To the extent that the relevant monuments of an original survey are missing, a surveyor must determine the boundaries and corners of the land surveyed by measurement in correct relation to

(a) adjoining or adjacent parcels of land, and
(b) parcels of land on opposite sides of roads, and
(c) fences, and
(d) such other evidence of correct location as may be found after full investigation and inquiry.

Consequently, when original marking, be it corner mark or reference mark, from the creation of a street is gone, then a pattern of response is activated by the incoming surveyor (de Belin, 2016). The surveyor will rely on old or substantial fencing or building occupations found at street intersections and bends, then place new marks in response to the survey. When old occupations and the new marking are gone, then the surveyor will rely on new occupations and place even newer marks. The cycle repeats itself. The obvious outcome is that the cycle of street fixing may result in a moving of the position of the street boundaries (de Belin, 2015).

At intersections where marking has been lost for decades and best estimates have been the only thing holding the cadastre together, who has the right or obligation to say where a street boundary is sited? Registered surveyors? NSW Land Registry Services (LRS) and the lawyers? Local councils?

Registered surveyors gather up the evidence and offer a best estimate of the boundary based upon what evidence is found. They are continuously attempting to maintain a structurally sound cadastre and call themselves custodians of the cadastre. LRS is interested in the plan purpose and how the new plan fits into its system of the cadastre. LRS calls itself the custodian of the cadastre. Unless it is specifically a street re-definition plan, a local council has no say. That is not to say that local councils are not keenly interested in having street boundaries retained in their original location and original street width.

4 TRAPPING THE BEAST

Binding plans of survey to a national coordinate system was seen as a definitive method which would enable consistent re-establishment of street boundaries. This may work well for newly created streets and carry onwards, but the bulk of the NSW cadastre is not yet tied to the Map Grid of Australia (MGA) and the Geocentric Datum of Australia 2020 (GDA2020). In the City of Ryde, where less than 20% of its land parcels are tied to MGA, there have barely been a dozen new streets created since 1975! This means that over 850 streets were in existence before 1975, and it is from this pool that street definition differences and difficulties will arise. Can these definitions be trapped and controlled before they too are locked onto the MGA?

Returning to the two examples discussed previously, is there a way to establish and hold a street boundary in place? At Denistone Avenue many occupations, houses and structures are visible and usable at its intersections (Figure 24). A street intersection, by its very nature is generally free of vegetation, which therefore provides clear sight lines at an intersection. This setting is ideal for terrestrial laser scanning to enter the scene and collect a wealth of data at intersections and bends (Figure 25). With ongoing construction, as shown in Figure 25, it would be better to defer any scanning at the bend until the new construction is completed and there is a new building in place ready to survive for many decades.

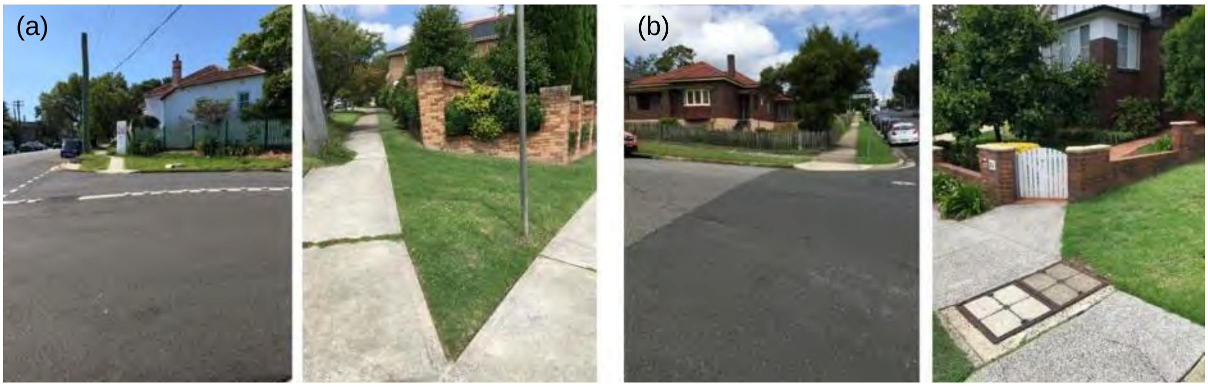


Figure 24: (a) T-intersection of Denistone Road at Ryedale Road (2023), and (b) T-intersection of Denistone Road at Dalton Avenue (2023).

Figure 25: Built and building environment at the bend in Denistone Road (2023).

At the intersection of Pittwater Road and Magdala Road (Figure 26) such a terrestrial laser scan has been undertaken by the City of Ryde.

Figure 26: Intersection of Pittwater Road and Magdala Road (2023).

Detail from the scanned information at this intersection is shown in Figure 27. Data was obtained using a quadrilateral of station set-ups, which enabled data points to be collected to a cadastral accuracy of well under 5 mm. This is considered a suitable technique to validate and confirm data for 20 metres up each road away from the intersection. Connection to Survey Control Information Management System (SCIMS) control marks meant that a full MGA coordination was possible and achieved.

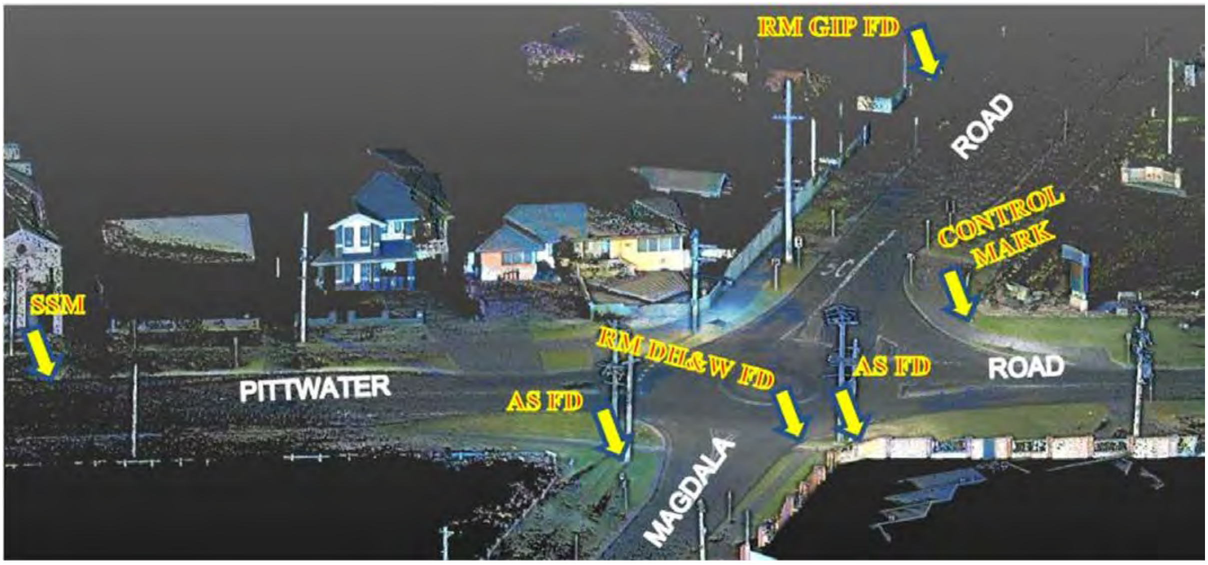


Figure 27: Scanned detail at the intersection of Pittwater Road and Magdala Road (2023 scan).

Figures 28 & 29 show some of the detail obtained from the intersection scan, from the North Ryde RSL signage pillar and its artillery monument to a newly constructed residence, which should remain for decades.

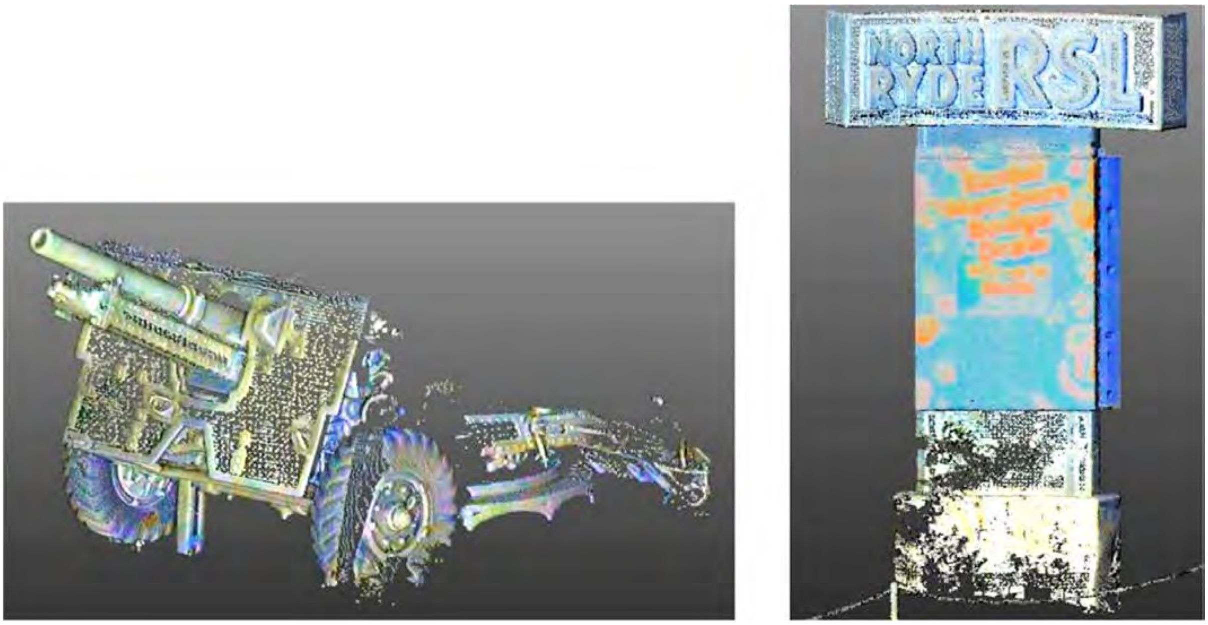


Figure 28: Scanned detail on the North Ryde RSL site (2023 scan).

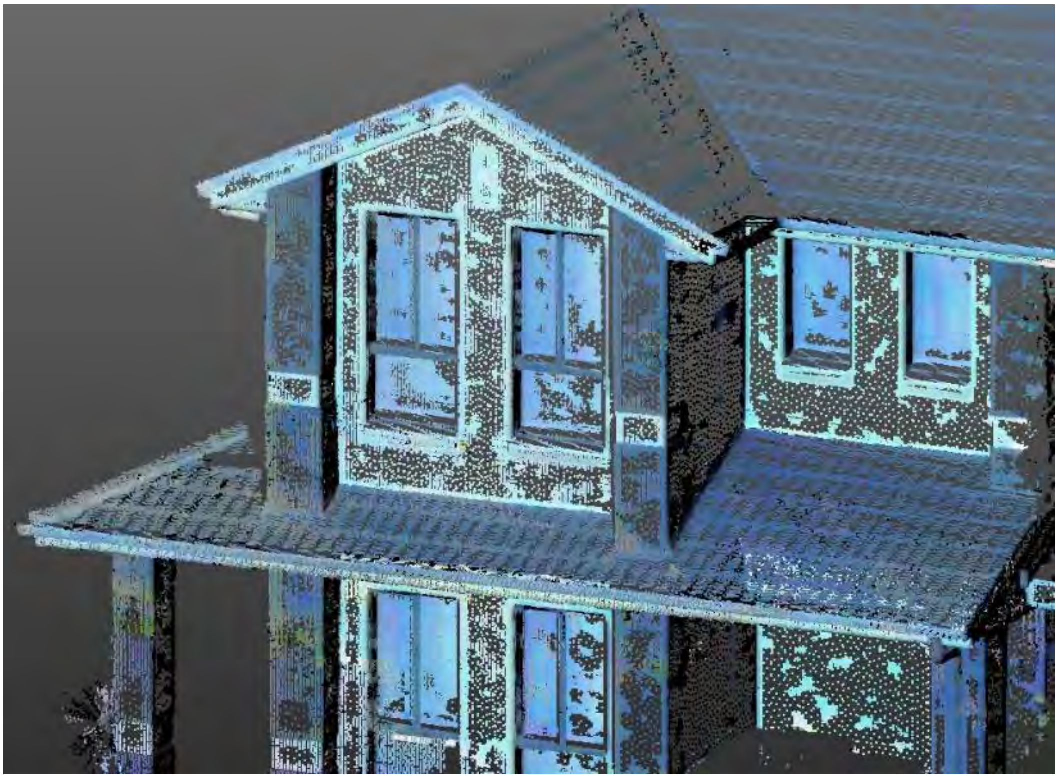


Figure 29: Scanned detail on newly built residence (2023 scan).

Close up detail of the scanned data shows some of the many overall points, which can be used for future reference to establish the road boundary lines (Figures 30 & 31). The step-out in the brick fencing pier enquires at 240 mm from the scanned data and measures 240 mm by tape measure.

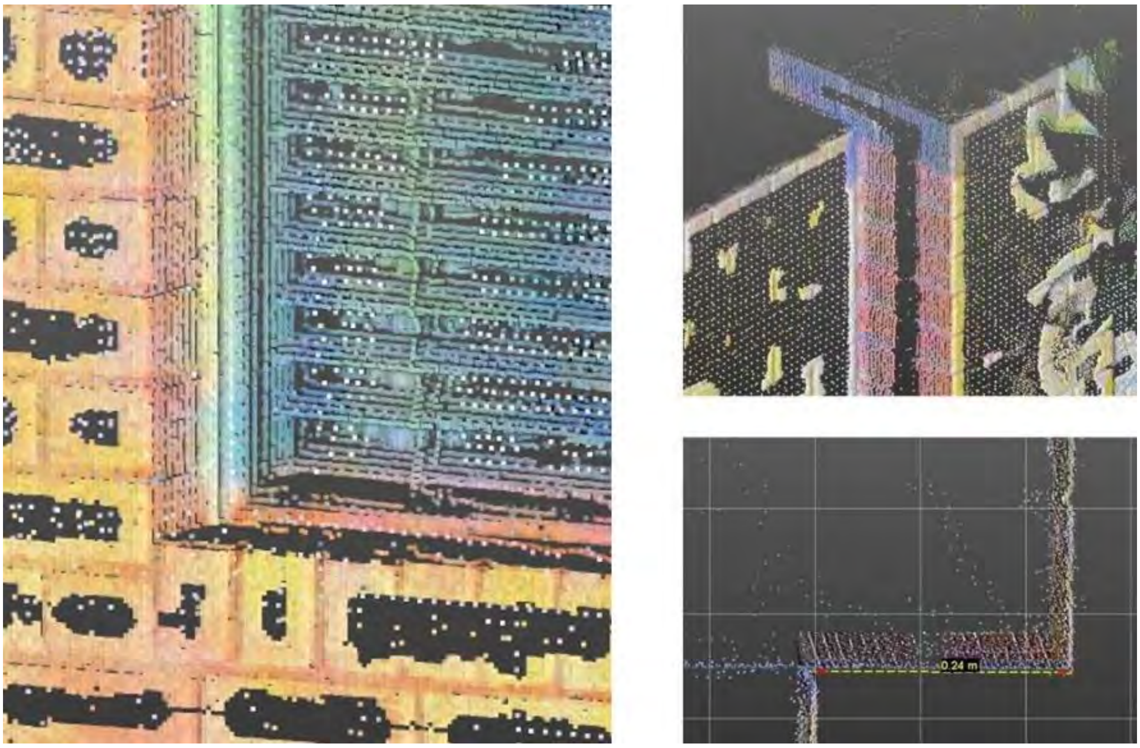


Figure 30: Scanned detail on window frame and edge of brick fencing pier (2023 scan).

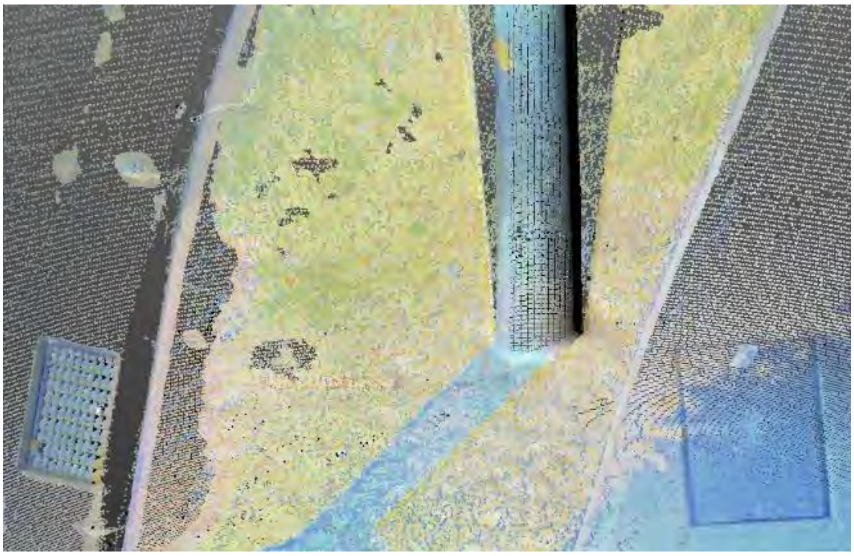


Figure 31: Scanned detail of a metal stormwater grate and a telecommunications pit in the footpath (2023 scan).

5 TAMING THE BEAST

Traverse measurements between several known reference marks and coordinated SCIMS marks are essential to fitting the scanned data to the cadastral framework (Figure 32).

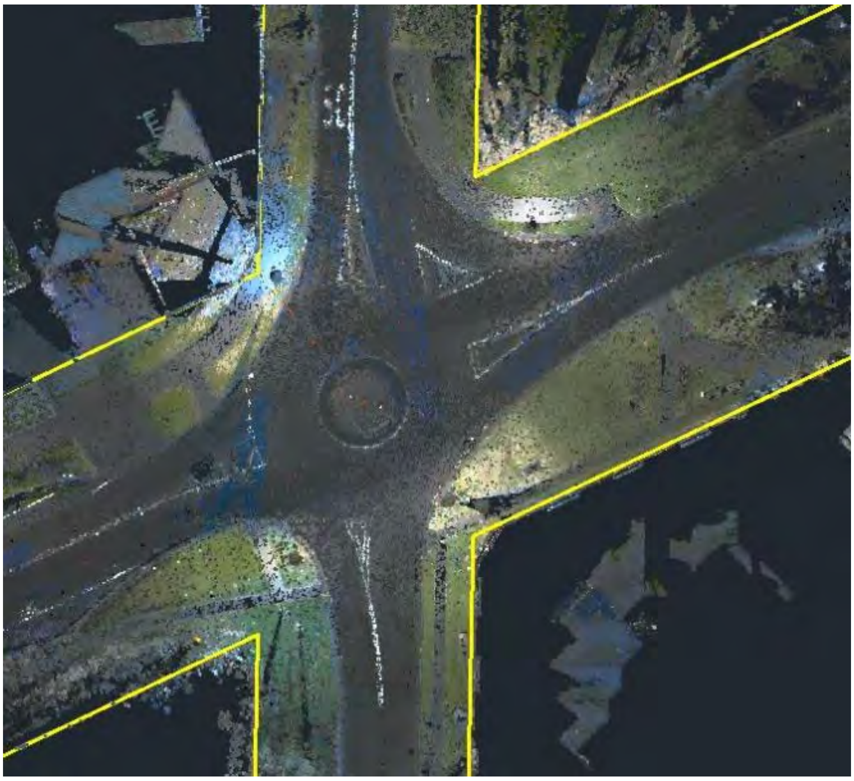


Figure 32: Scanned data fitted to street corner cadastral boundaries (2023).

Where disputes and disagreements about a street fix are unlikely and where the street is still in the position as created, there would appear to be no real urgency in locking down the intersection. In the future, Google Maps and Street View (in whatever form they take) could verify what still exists at an intersection. Check Google Maps and Street View to see the current state of the street intersection, then upload any relevant points of scanned data to the field controller before using this data to establish a street intersection corner.

Surveyors must be left to make a best estimate of boundary position based on sound and thorough investigation. LRS insisting on complete agreement with a previous already registered plan is not only an easy way out, but is wrong and setting the cadastre up for failure with major zones of conflict.

What is the industry solution and the council solution to a lost intersection? The City of Sydney had this problem in the past. Following first grants, a multitude of constant development and change with rapid loss of survey infrastructure occurred. Occupations became king, a situation which led to the City of Sydney becoming a consent authority, who had the sole power to approve any street boundary determination within its city limits.

What can other councils do?

- Create a plan for a street re-definition showing the most valid fix at a street intersection.
- Maintain a documented history of the relevant DPs, which created their streets in the first place.
- Place a PM at the intersection if a SCIMS mark does not already exist.
- Scan an image of the street intersection for modelling and providing a locality sketch for SCIMS marks placed (there are 85,000 ‘class U’ SCIMS marks which rely on a locality sketch only as a means of finding where they are sited – this is 32% of the marks in the SCIMS database!).

7 CONCLUDING REMARKS & THE BIG EASI

Uncertainty of knowing just what will survive and last, and still be present at a street intersection after several or many decades is the constant problem which needs to be overcome. Time is the enemy. Knowing that things will change, the built environment will become altered and survey marks will be lost and destroyed, gives surveyors a chance to minimise the effect of such changes. Preservation of Survey Infrastructure (POSI) should play a major part in the protection of survey marks, but is POSI really preserving the true corners and boundaries when so many of the survey reference marks are not connecting to a correctly defined street fix or corner?

City of Ryde is not advocating any changes to the current position of side boundaries of lots as determined and fixed by survey. Any side boundary created in relation to an incorrect street fix should remain in its created position, even if the street definition changes and the street boundary line is altered. It is acknowledged that there may be some problems in relation to re-establishing old boundaries which had an angular relationship to the original street boundary.

This is about local councils and surveyors ‘Reclaiming the Streets’ as a solid coordinated network with which to maintain a sound cadastre. In Ryde, not all streets are in their original created position anymore. But for the future, if intersections are scanned now, then the data could be available for decades, because not all of the referenced points and occupations will disappear. This paper has suggested terrestrial laser scanning as a means of protecting and retaining council road assets rather than have them be a dumping ground or repository for past inaccuracies and not fully informed decisions with respect to street boundary fixing. A final point of reference is the big EASI: Just get Everything At Street Intersections!

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