SunWater
MAKING WATER WORK

University of Southern Queensland

Faculty of Engineering and Surveying

Development and Evaluation of a Field Mobility Data Capture System for Condition Assessment of Assets

A dissertation submitted by

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In fulfilment of the requirements of

Course ENG4111 & ENG4112 Research Project

Towards the degree of

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ABSTRACT

The principle aim of the research was to determine if a mobile data capture system could be suitably applied to the condition assessment of assets within SunWater.

The study involved research into the current condition assessment process within the Irrigation & Drainage department of SunWater. Assets considered in this project involved those specific to the Barratta Section of the Burdekin Haughton Water Supply Scheme (BHWSS). This research involved the engineers and technical officers of the Asset Management, Irrigation & Drainage department within SunWater.

Established during this research was the current condition assessment process, possible mobile data capture solutions to this process and a trial of a mobile data capture system within the Barratta Section of the BHWSS. The associated costs of the current process and mobile solutions were then analysed making use of the outcomes of the trial. From this analysis, conclusions were able to be drawn as to the relative merits of mobile data capture systems and their usefulness to SunWater.

The physical output of the research included a trial application for the completion of asset condition assessments and a recommendation on the economic viability for implementing a mobile data capture system within SunWater.

The results of this study will help to determine if SunWater can incorporate mobile data capture systems into its condition assessment processes and thereby support its productivity initiative of 'Smarter, Lighter, Faster.'

University of Southern Queensland

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Fiona Jane Nielson

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_____ Date

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ABBREVIATIONS

The following abbreviations have been used throughout the text:

BHWSS	-	Burdekin Haughton Water Supply Scheme
GOC	-	Government Owned Corporation
GIS	-	Geographical Information System
SAP	-	Systems, Applications and Products
ESRI	-	Environmental Systems Research Institute
ARMS	-	Asset Register and Management System
OS	-	Operating System
IP	-	Ingress Protection

1.0 INTRODUCTION

1.1 OUTLINE OF THE STUDY

This study investigates the development and evaluation of a field mobility data capture system for condition assessment of assets within the water industry. It looks at the current condition assessment process and how this can be improved through the use of mobile data capture systems. This includes investigation into types of mobile devices and software platforms.

The main focus of the study is to develop and trial a mobile data capture system in the BHWSS to determine the benefits, of implementing such a system. The purpose of the study is to report on the outcomes of the trial, and analyse the results to provide a recommendation to pursue or otherwise mobile data capture of asset condition within SunWater.

1.2 INTRODUCTION

1.2.1 SunWater Ltd

SunWater Ltd is a Queensland based Government-Owned Corporation (GOC) which was formed in 2001. SunWater's extensive network of water supply infrastructure supports mining, power generation, industry, urban development and irrigated agriculture throughout Queensland (SunWater 2013).

SunWater owns and manages around $7 billion in water infrastructure assets and supplies approximately 40% of all water used commercially in Queensland (SunWater 2013).

SunWater has an extensive infrastructure base including (SunWater 2012):

19 dams, 68 weirs and barrages, 85 major pumping stations and over 2500km of open channel and pipeline (Figure 1.1).

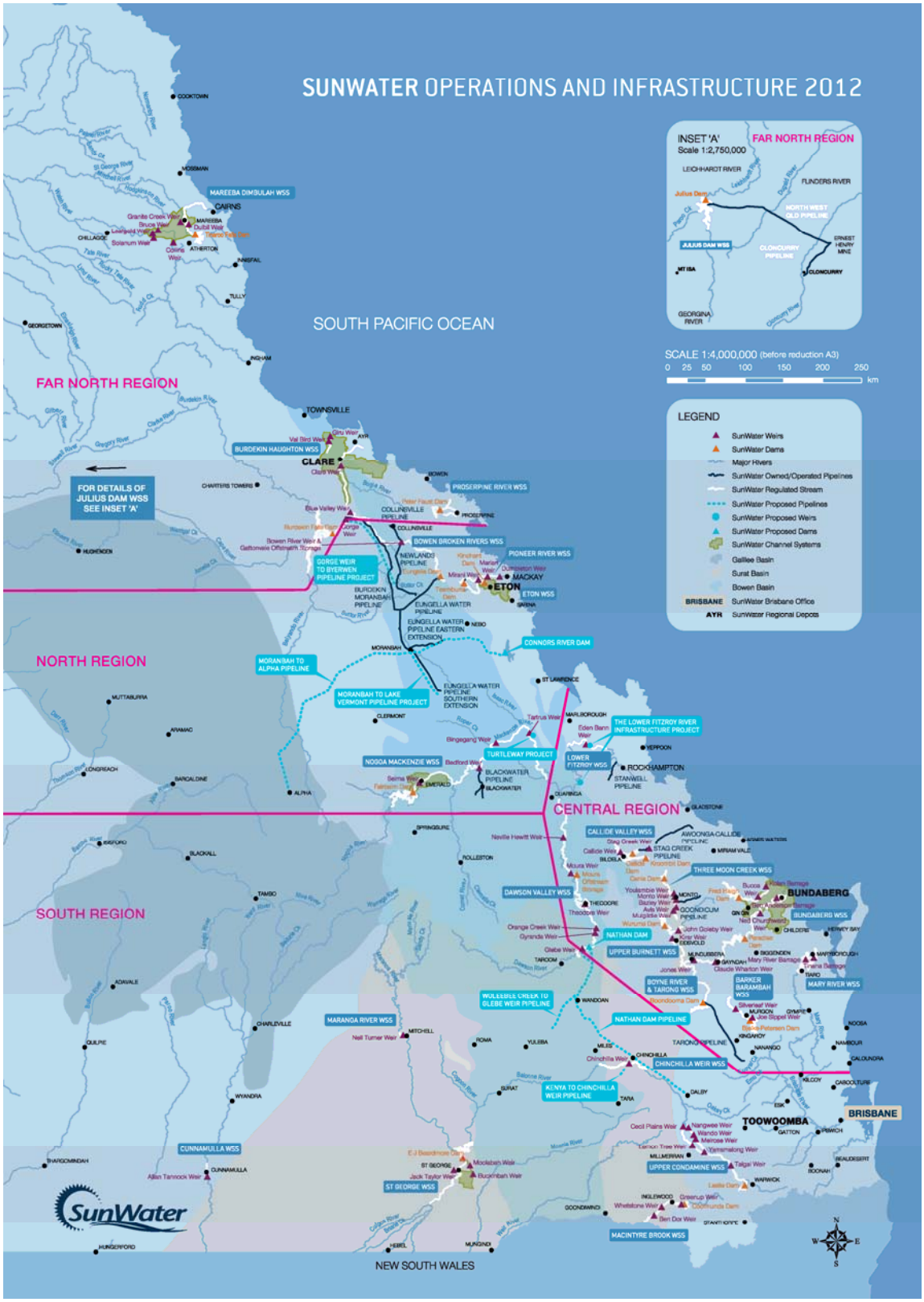


Figure 1.1 - SunWater Operations and Infrastructure (SunWater 2012)

1.2.2 Asset Management

The extensive array of infrastructure present under SunWater ownership requires thorough asset management. SunWater's aim is "To manage our assets in a sustainable manner to meet SunWater's business objectives of safeguarding asset integrity and ensuring asset serviceability." (Asset Management Policy AM01_P1 2013). In order to achieve this SunWater must carry out certain tasks, one of which is performing condition assessments of all assets and recording these assessments in SunWater's corporate system.

1.2.3 Condition Assessment

Condition Assessment is the process by which an asset's condition is objectively reviewed against a defined criteria set and the results recorded for later review and analysis. In the SunWater's case, the data is stored within an SAP database.

Its purpose is 'to establish a consistent, informed and auditable process for prioritising expenditure on asset refurbishment based on the assessment and management of asset condition.' (Asset Refurbishment Planning: Methodology for Condition Assessments of Assets 2012).

1.3 THE PROBLEM

Since the development of the first irrigation areas in the 1950's, SunWater's infrastructure base has continued to expand through growth in the agriculture sector, but also more recently the boom in the Queensland mining/industrial sector. As a result, extensive pipeline and pump station assets have been added to the asset portfolio.

In 2000 SunWater upgraded its Asset Register and Management System (ARMS) to SAP PM (Systems, Applications and Products Plant Maintenance). With the implementation of this new management system, it was decided that a whole of SunWater asset condition assessment would be necessary to ensure the asset data in the new system was accurate and up to date. A large number of the assets owned by

SunWater require condition assessments every 10 to 15 years. This means that these assets will now be due for assessment or will be nearing assessment in 2015. Due to this large number of assets, a more economical solution could provide significant cost benefits over the earlier efforts.

In order to uphold the required standard of asset management across such a broad asset base, it is important that alternative methods of data collection are investigated and thereby allow SunWater to achieve a productivity improvement ('Smarter, Lighter, Faster').

At present, the condition assessment process is distributed between sub-departments of the Asset Management Group (Figure 1.2). The group is broken down into asset specific departments, these being:

Dam Safety – Ensure that SunWater complies with the necessary regulatory requirements.

Asset Information Policy and Standards – Develop and maintain the Asset Management Policy and Standards framework and ensure compliance across all groups.

Pumps and Pipelines – Manage the pump stations and pipeline assets (i.e. Industrial pipelines and all pumpstations)

Irrigation and Drainage – Manage the irrigation and drainage assets (i.e. Channels and associated infrastructure)

Headworks – Manage the water storage assets (i.e. Dams and weirs)

The last three asset groups are all required to perform condition assessments of their relevant assets. For the purposes of this thesis, the focus will be on the methods and

processes utilised by the Irrigation and Drainage group. It is expected that the outcomes of this report will be considered by SunWater as part of its continual improvement initiatives.

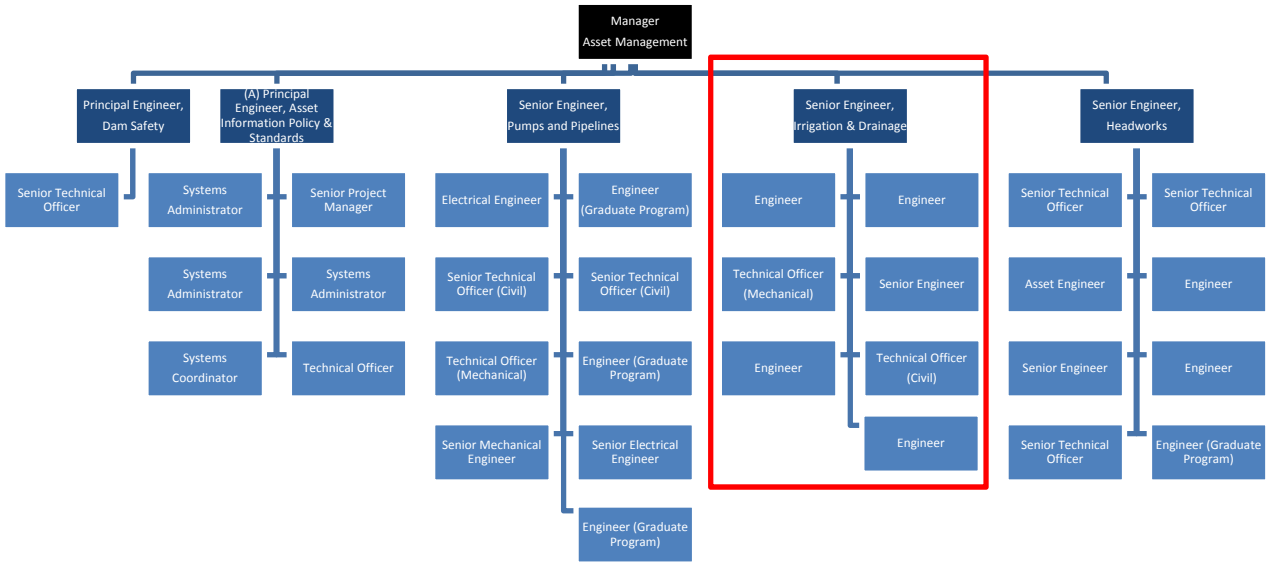


Figure 1.2 - Asset Management Organisational Hierarchy (SunWater 2013)

The current condition assessment methods that are employed by SunWater are eligible for efficiency improvements and are the catalyst for this thesis as discussed in Section 0.

1.4 RESEARCH OBJECTIVES

The principle aim of this research is to develop and trial an application that will enable electronic recording of asset condition assessments in the field. This trial will aid in determining whether there are benefits in advancing with such a system within SunWater.

There are nine objectives associated with this aim (as per the specification, APPENDIX A):

1) Undertake a basic requirements analysis, identify use cases and develop a platform functional specification:

2) Undertake a comprehensive literature review covering but not limited to the following aspects:

- The range of commercially available field mobility solutions:
- Industry user types, market requirements and directions;
- Types of software available, trends and support prospects;
- Types of hardware (i.e. tablet, phone. other), functionality and design obsolescence; and
- Advantages/Disadvantages of software/hardware/field data capture packages.

3) Develop an optimised prototype system incorporating a software solution/hardware package that satisfies SunWater's functional requirements. Engage the services of a third party to develop software/hardware solutions as required.

4) Develop and implement a test plan for developed software and hardware component. Undertake field trials and review performance against functional requirements;

5) Prepare an academic dissertation of the research project;

As time permits

6) Analyse and evaluate business processes in relation to the developed system.

7) Undertake cost/benefit analysis of implementing the field mobility solution in the context of asset data capture and analysis;

8) Subject to positive outcome of point 7), prepare a draft business case for the Implementation of the system within SunWater asset management; and

9) Provide recommendations on the implementation of the system and the final functional and technical specifications.

By meeting each of these objectives a suitable outcome can be reached to enable SunWater to make an informed decision on the use of mobile data capture systems to aid or replace current manual processes.

A timeline was also produced for this research project with appropriate target dates to aid in successful completion of the above objectives. This can be seen in APPENDIX K.

1.5 SUMMARY

SunWater's business of operating and maintaining assets requires effective and efficient processes and procedures. An element of these processes and procedures involves the condition assessment of assets. This process helps to document valuable asset information however can be at a considerable financial and resource cost to SunWater.

To date SunWater has utilised only small components of mobile data capture within the organisation without a huge emphasis on progressing in this area. It is therefore the aim of this study to develop and trial one of these systems to determine if this is an area of growth for SunWater.

2.0 BACKGROUND INFORMATION

2.1 RESOURCE PLANNING

The successful completion of this project will require a number of resources. For the purposes of this project it has been decided to utilise hardware and software that is already available within SunWater in order to complete the trial.

The hardware that will be utilised is a personal apple iPad tablet. This device was manufactured in 2011 and is suitable to the outdoor conditions that will be faced during the field condition assessments. This device is currently accessible and will be available for the duration of the study.

SunWater utilises ESRI's GIS packages which include ArcMap and GIS Server packages. This also includes the licensing for ArcGIS Online and the Collector App which is the software that will be utilised for the trial. As the iPad is iOS based the two complement each other and will be suitable for the trial.

As an employee of SunWater since 2005 I have had extensive exposure to ESRI's GIS systems and will be capable of creating maps and mapping interfaces suitable for condition assessment of assets within the BHWSS. Due to my current role as technical officer I have access to the appropriate licences and computer to complete the required tasks.

The trial data capture system will be utilising hardware and software that is already available to SunWater so the study will not be imposing any extra costs to SunWater.

2.2 THE CONDITION ASSESSMENT PROCESS

As mentioned previously (Section 1.3) this study will be analysing the condition assessment process adopted by the Asset Management, Irrigation & Drainage Group. Figure 2.1 and subsequent sections show and explain the processes which are currently utilised by Irrigation and Drainage.

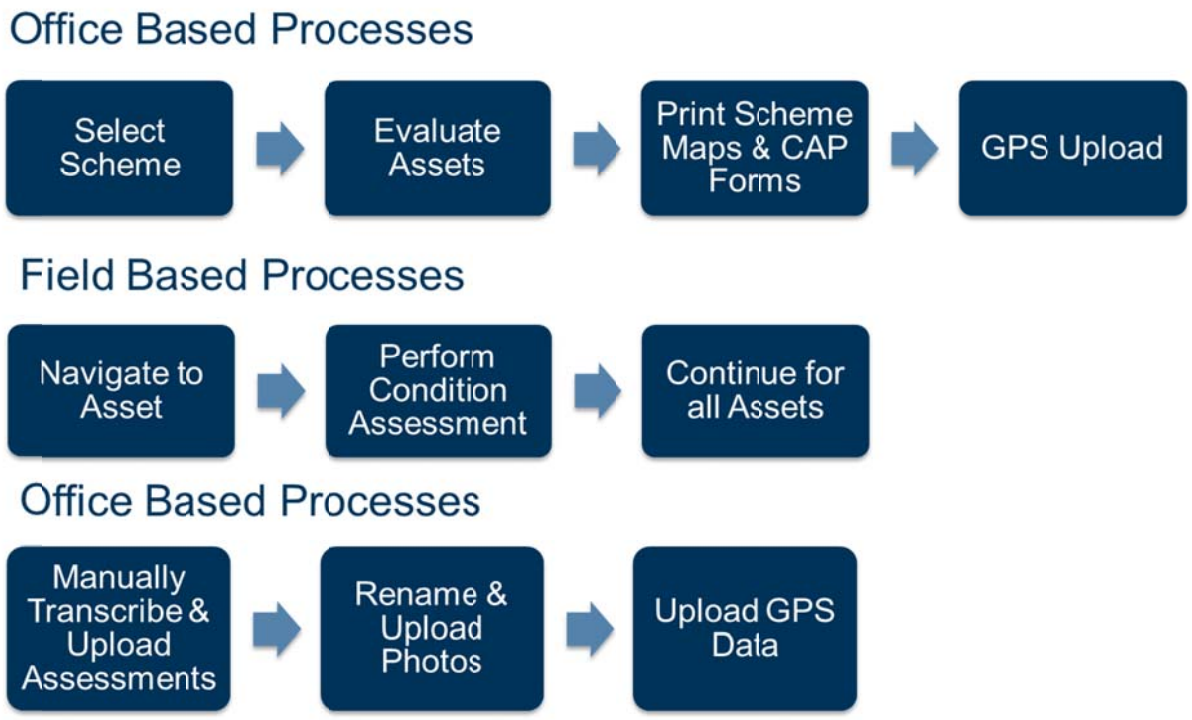


Figure 2.1 - Manual Condition Assessment Process

2.2.1 Select Location

The first step in carrying out a condition assessment is to determine the location. The Irrigation & Drainage Group services all water supply schemes within SunWater and so completes condition assessments in each scheme yearly. The location and timing of these assessments is dependent upon shutdowns, staff availability and emergency assessments (i.e. flood events).

2.2.2 Evaluate Assets

Once the scheme is selected an evaluation process is carried out to determine which assets need to be assessed. Typically field condition assessments will last for three days with the aim of assessing 50 assets per day. The assets are selected by sorting them on a number of criteria:

1 – Has the asset ever been assessed.

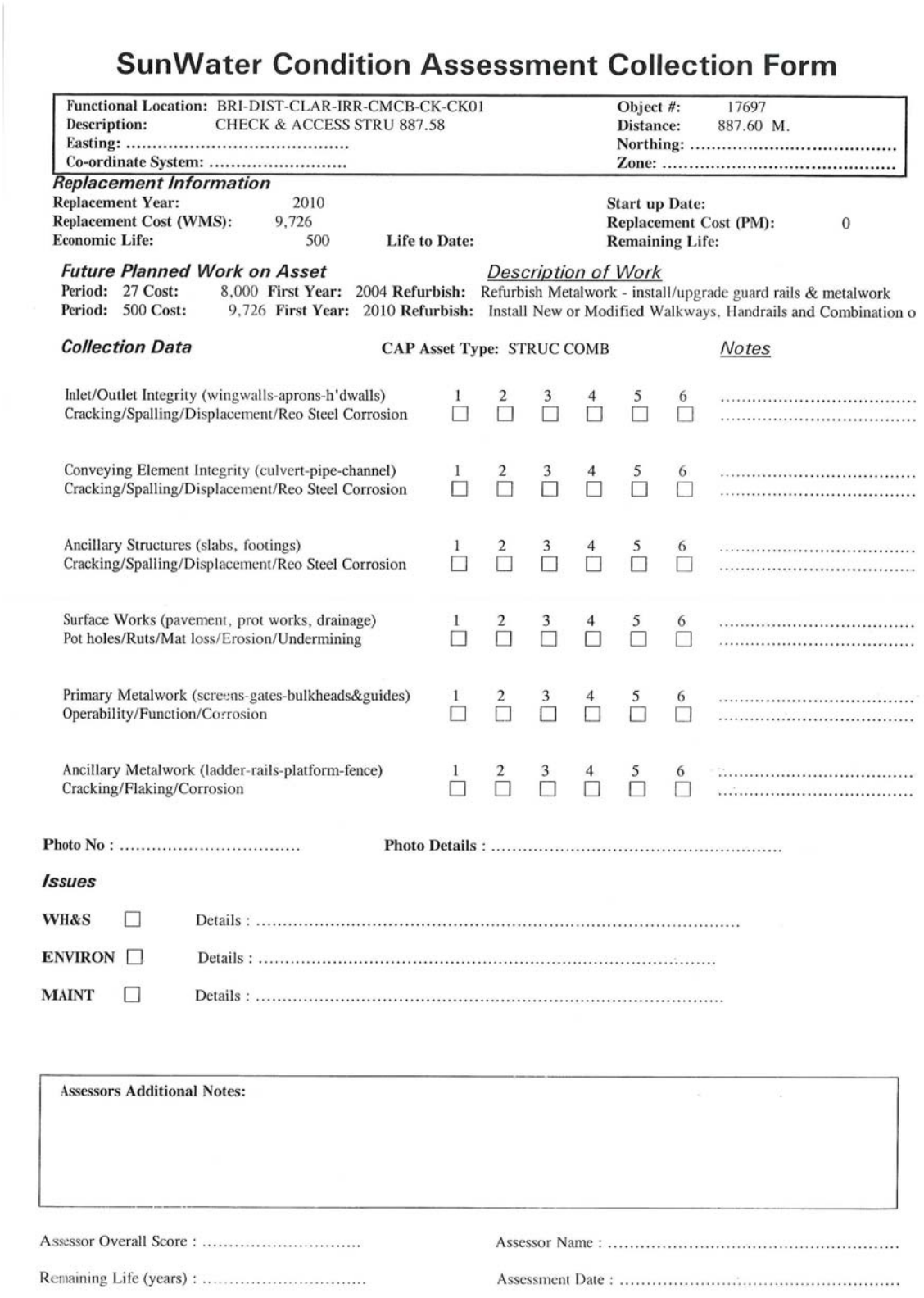
2 – Is the asset due to be assessed.

3 – Has an assessment been requested.

Our corporate data system enables us to sort on these criteria and select a suitable range of assets to assess.

2.2.3 Print Scheme Maps and Condition Assessment Forms

Condition Assessment Forms for each asset are then printed, hole punched and placed in folders for transportation in the field (Figure 2.2).



SunWater Condition Assessment Collection Form

Functional Location: BRI-DIST-CLAR-IRR-CMCB-CK-CK01 **Object #:** 17697
Description: CHECK & ACCESS STRU 887.58 **Distance:** 887.60 M.
Easting: ..... **Northing:** .....
Co-ordinate System: ..... **Zone:** .....

Replacement Information

Replacement Year: 2010 **Start up Date:**
Replacement Cost (WMS): 9,726 **Replacement Cost (PM):** 0
Economic Life: 500 **Life to Date:** **Remaining Life:**

Future Planned Work on Asset *Description of Work*

Period: 27 **Cost:** 8,000 **First Year:** 2004 **Refurbish:** Refurbish Metalwork - install/upgrade guard rails & metalwork
Period: 500 **Cost:** 9,726 **First Year:** 2010 **Refurbish:** Install New or Modified Walkways, Handrails and Combination o

Collection Data **CAP Asset Type:** STRUC COMB *Notes*

	1	2	3	4	5	6	
Inlet/Outlet Integrity (wingwalls-aprons-h'dwalls) Cracking/Spalling/Displacement/Reo Steel Corrosion	☐	☐	☐	☐	☐	☐	....
Conveying Element Integrity (culvert-pipe-channel) Cracking/Spalling/Displacement/Reo Steel Corrosion	☐	☐	☐	☐	☐	☐	....
Ancillary Structures (slabs, footings) Cracking/Spalling/Displacement/Reo Steel Corrosion	☐	☐	☐	☐	☐	☐	....
Surface Works (pavement, prot works, drainage) Pot holes/Ruts/Mat loss/Erosion/Undermining	☐	☐	☐	☐	☐	☐	....
Primary Metalwork (screens-gates-bulkheads&guides) Operability/Function/Corrosion	☐	☐	☐	☐	☐	☐	....
Ancillary Metalwork (ladder-rails-platform-fence) Cracking/Flaking/Corrosion	☐	☐	☐	☐	☐	☐	....

Photo No : ..... **Photo Details :** .....

Issues

WH&S ☐ Details : .....
ENVIRON ☐ Details : .....
MAINT ☐ Details : .....

Assessors Additional Notes:

Assessor Overall Score : ..... Assessor Name : .....
Remaining Life (years) : ..... Assessment Date : .....

Figure 2.2 - Example Condition Assessment Form from SAP (SunWater 2013)

The next step is to locate the relevant scheme maps and if necessary update to include selected assets and print (APPENDIX B).

2.2.4 Upload Locations to Handheld GPS

The assets also need to be uploaded to handheld GPS to enable easier location in the field. The GPS must be cleared of all existing data and new data uploaded. This process can take a considerable amount of time due to the inconsistencies between our corporate GIS system and our corporate data system. Any assets that aren't currently included in SunWater's GIS system are located using tools within ArcMap and added to the GPS.

2.2.5 Field Condition Assessment

Once the above processes are complete staff are able to travel to site to assess each asset. This involves:

Location of specific asset utilising A3 scheme maps (APPENDIX B) and handheld GPS. This form of navigation requires more than one person and so all condition assessments are completed with two staff members. This is also a safety precaution due to the remote locations of some assets.

Once the asset is located the condition assessment on the asset is carried out by manually filling out the condition assessment forms on site (Figure 2.2). Each criteria on the condition assessment form is given a rating from 1 to 6. These criteria and examples of ratings are provided in the 'Condition Assessment of Civil Assets' manual which is to be referred to before making an assessment. Refer to APPENDIX H for an example excerpt from this manual.

A photo of the asset is then taken with a handheld camera and the photo number recorded on the condition assessment form. A GPS location is also taken with a handheld GPS and the waypoint recorded on the condition assessment form. This process is continued for all assets.

2.2.6 Upload of Condition Assessment

Once back in the office the condition assessments must be recorded on our corporate systems. This is a considerable process and must be completed manually.

To begin with, each of the condition assessment forms need to be manually transcribed into a pre-formatted spreadsheet (APPENDIX C). This process must be carried out for all 150 assets.

The next process is to rename each photo (150 photos or more) with the asset's specific object number and description. The object number is a unique identification number that helps to identify an asset.

Finally the GPS locations of each asset are uploaded and manually renamed for inclusion in our corporate GIS system.

Once complete the result is an asset that is linked to an up to date condition assessment with photo and accurate GPS location.

The entire process is a manual one with transcription of data occurring numerous times. This double handling and intense manual interaction leaves room for human error and results in a time consuming process.

It's worth noting that the entire process is carried out by technical officers and engineers with no assistance from administration resulting in quite a costly procedure for SunWater.

A tabulated breakdown of the processes involved and the time to complete these condition assessments can be seen in Table 2.1 below.

Table 2.1 - Condition Assessment Cost Breakdown per Scheme

Current Condition Assessment Process per Scheme

TASK	TIME (Hours)	RATE	UNIT	TOTAL
PREPARATION				
Select scheme to be assessed. Select assets to be assessed based on: - Condition assessments due - Risk of asset (i.e. high risk, high priority) - No previous assessment recorded - Planning items due Print Condition Assessment Forms for all assets, hole punch and place in folders. *Usually select around 150 assets for a 3 day condition assessment. Work on 50 assets per day.* Extract the gps location of these assets from our GIS data and load onto GPS. This data is not complete and often assets cannot be found. The naming convention between the two systems also creates difficulty in finding assets. Ensure a hardcopy set of scheme maps is available and up to date. If not update and reprint. Organise vehicle and equipment Complete Work Method Statement	20	SW06	2	$2,280.00
CONDITION ASSESSMENT				
When on site travel to each site and condition assess each asset. Take a photo and GPS point also. *For a 10hr day with 50 assets that's approximately 12 minutes to assess each structure and travel to the next one.*	30	SW06	2	$3,420.00
POST PROCESSING				
In the office manually input condition assessment data from forms into spreadsheet and upload. Upload GPS points and update Corporate GIS data. *Correlation between GPS waypoint number and CAP forms is a very slow process.* Upload photos and rename using photolink software. *Correlation between photo number and CAP forms is a very slow process.*	15	SW06	1	$855.00
TOTALS	**45**	**-**	**-**	**$4,275.00**

The process described in this table encompasses only the actual condition assessment process and does not take into account other overheads such as travel costs, accommodation costs, etc.

This financial breakdown is for one water supply scheme. Typically Irrigation and Drainage would be spending a week long condition assessment at seven different schemes per year. When inclusion of travel costs is considered data from the 2012/2013 condition assessments estimates this figure to be $90,000 for seven schemes per year (APPENDIX D). When you extrapolate this data across the assets assessed this equates to approximately $109.00 per asset.

It is predicted that the implementation of a mobile device for recording of these condition assessments would result in considerable savings for SunWater. This will be evaluated once a complete trial has been carried out following the methodology discussed in Section 4.0.

2.3 WHAT DOES SUNWATER REQUIRE

As previously mentioned the purpose of this thesis is to investigate improvements of the above described condition assessment process through the implementation of a mobile data capture system. In order to do this it is imperative that SunWater's requirements are considered in a bid to enable productive investigation.

2.3.1 Requirements Analysis

The successful implementation and uptake of this system requires examination of the needs of not only SunWater but also the end user.

The first point to consider is the type of device and software that would be most suitable for the process.

The device will be used outdoors in dusty and wet environments with the possibility of drops onto hard surfaces so it's evident that some form of rugged device is necessary. It also needs to be visible in the sun and hence requires some form of anti-glare measure.

In terms of software SunWater currently utilises SAP for its asset data information and ESRI's ArcMap for capture and storage of geospatial information. It would be ideal to have a software package that incorporated both of these systems so there was a seamless update of data across the board.

The user interface needs to appeal to the end user but also needs to easily perform its function of recording condition assessments and associated capture such as photographs and GPS locations. It is essential that all three of these actions are included in the one system to ensure efficiency improvements.

Section 3.2.1 provides a breakdown of points for consideration before implementation of such a system. These points will be considered throughout the investigation in a bid to produce a fit for purpose system for SunWater. In short these points suggest the system needs to be able to work offline and re-synch when coverage returns, ensure

that no data loss occurs through device failure etc, ensure that the software is platform independent and can work on any operating system and that overall the system is better than pen and paper.

The system needs to be more efficient than the current process however these efficiencies need to positively outweigh any costs associated with the implementation and support of the proposed system.

SunWater's budget will be the final deciding factor on many of these points. For the purposes of the trial system a personal mobile device and pre-existing software will be utilised.

APPENDIX E and APPENDIX F show a matrix of the criteria that the hardware and software solutions were rated against. In order to make an information decision about which software and hardware is suitable these criteria have been given a rating system that will provide an overall scoring for each hardware and software solution effectively ranking them and providing a clear picture of which solutions are most beneficial for SunWater.

2.3.2 Hardware Ranking

When investigating the hardware solutions available for SunWater the following criteria were specified:

Rugged Enclosure Required; Operating System; Water Resistant; Multipurpose; Shock Resistant; Gorilla Glass; Touchscreen/Stylus; Screen Size; Sunlight Visibility; Ingress Protection (IP) Rating; GPS; Camera; Megapixels; Battery Life; Network; Storage Size; Cost per Unit.

Each of these criteria were relevant to SunWater requirements however there are certain criteria which are more desirable than others and these were ranked accordingly. The ranking was established so that each criteria was related to a score and these scores could then be accrued to establish a final score or ranking for comparison. It was decided that 0 would be the base neutral score with negative

criteria outcomes resulting in negative values and positive outcomes resulting in a score of 1 or more. Refer

Figure 2.3 below for a visual representation of this scoring metric.

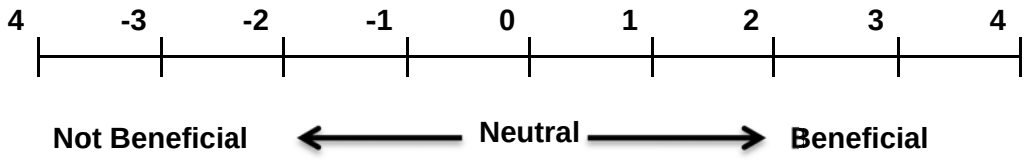


Figure 2.3 - Criteria Scoring Number Line

A breakdown and explanation of each criteria along with its scoring metric can be seen in

Table 2.2.

Final outcomes for each of the hardware devices researched and their final ranking scores will be discussed in the results in Section 5.4

Table 2.2 - Hardware Criteria Breakdown and Scoring

Criteria	Explanation	SunWater's Preference	Outcome	Score
Rugged Enclosure Required	Is a separate rugged enclosure required or does the device already encompass a built-in ruggedised eclosure as part of the device?	This criteria would depend on the cost of the enclosure. SunWater does require some form of enclosure if none is supplied with the device. It is however not necessarily more beneficial for this enclosure to be built into the hardware as this often leads to a more expensive outcome overall.	Yes No	0 1
Enclosure/Cost ($)	If the device does require a separate enclosure what is the cost of this?	Research of current adequate enclosures shows a price range of approximately $80 to $150.	Cost < $100 $100 < Cost < $200 Cost > $200	2 1 -1
Operating System	What operating system does the device use?	This criteria has no real bearing on the outcome of the hardware. If a software decision was made and that software could only support certain operating systems then this criteria would have a large bearing on the hardware selection.	Operating System	N/A
Water Resistant	Is the device water resistant?	SunWater requires field hardware to be water resistant and this may be through either the use of an enclosure or the actual device may be resistant.	Yes No	1 -1
Multipurpose	Can the device be used for functions other than just field data collection?	It's beneficial for SunWater to have a device that can be used for other business functions as well as for condition assessments. Condition assessments consume approximately 20% of the year for Irrigation and Drainage its therefore beneficial for SunWater is this device can be utilised in other business areas.	Yes No	2 -1
Shock Resistant	Is the device shock resistant?	As this hardware will be used in the field it needs to be shock resistant and this may be through either the use of an enclosure or the actual device may be resistant to shock.	Yes No	2 -1
Toughened Glass	Does the device have a form of toughened glass either built in to the device or in the device enclosure?	It would be desireable to have a device that had some form of toughened glass as this would provide protection from cracking and perhaps device failure.	Yes No	1 0
Touchsreen/Stylus	Does the device offer the use of a touchscreen/stylus or both?	This depends on the end user and the size of the device. If the device is large enough that touchscreen is easily utilised then this would be the preference. It would be beneficial however if the device supported both options to allow the user the choice. Trials with stylus devices currently owned by SunWater have proven to be awkward and not ideal in the field.	Touchscreen Stylus Both	1 0 2
Screen Size (inch)	Is the screen of the device of adequate size?	It would be desirable for the screen size of the device to be at least 7 inch however smaller screens could be acceptable.	Size < 7 inch Size > 7 inch	0 1
High Visibility in Sunlight	Does the device have adequate visibility in sunlight to enable uninhibited use outdoors?	This is a requirement for SunWater as all condition assessments will be carried out in the field. There are ways to avoid this issue however high visibility will be scored as a benefit it it's available.	Yes No	2 -1
Ingress Protection Rating	Does the device have a suitable IP rating?	For the purposes of use within SunWater field operations it would be beneficial if the device had an IP rating of at least 65.	Yes No	1 -1
GPS	Does the device have an adequate GPS?	Accuracy for condition assessment can be within metres of the asset. High accuracy locations are not a requirement for condition assessments. This means that all mainstream GPS capabilities would be suitable.	Yes No	1 -1
Camera (Mega Pixel)	Does the device have a camera and if so how many megapixels?	It's essential that the device has a built in camera and the greater the megapixel of this camera the more positive the score.	1 < Megapixel < 5 5 < Megapixel < 8 8 < Megapixel No	0 1 2 -1
Battery Life (hours)	What is the battery life of the device?	10 hours battery life would be an ideal amount for SunWater as this would accommodate a full day of condition assessment without the need to charge.	1 < Battery Life < 4 4 < Battery Life < 6 6 < Battery Life < 10 10 < Battery Life	-1 0 1 2
Network	Does the device support the appropriate network connections?	It's essential that the device supports cellular networks as the location of SunWaters Water Supply Schemes do not allow for wi-fi connections.	Cellular Wi-Fi Both None	1 0 2 -2
Storage Size (GB)	What is the available storage of the device?	It's beneficial to have a storage base on the device that can support the storage of at least 150 photographs. This storage size will change depending on the camera megapixels but at least 16GB would be desireable.	<16GB >16GB	1 0
Unit Price (AUD $)	What does the device cost?	The cheaper the device the more beneficial for SunWater however this value will be assessed against the overall hardware score to produce an adequate solution.	0$ - $500 $501 - $1000 $1001 - $2000 $2000 >	2 1 0 -1

2.3.3 Software Ranking

When investigating the software solutions available for SunWater the following criteria were specified:

Handheld Device; GOS; Camera; SAP Integration; ESRI Integration; SAP/ESRI Integration; Multiple OS Systems; Offline Data Recording; Navigation.

As with the hardware criteria each of those listed above are relevant to SunWater requirements however some criteria are more desirable than others. An identical scoring system to that of the Hardware Ranking in Section 2.3.2 was applied.

A breakdown and explanation of each criteria along with its scoring metric can be seen in Table 2.3.

Final outcomes for each of the hardware devices researched and their final ranking scores will be discussed in the results in Section 5.5.

Table 2.3 - Software Criteria Breakdown and Scoring

Criteria	Explanation	SunWater's Preference	Outcome	Score
Handheld Device	Does the software support handheld devices?	This is essential.	Yes No	1 The software cannot be considered.
GPS	Does the software support the use of GPS?	This is highly desirable as one of the aims of the project eliminate the use of multiple forms of hardware.	Yes No	1 -1
Camera	Does the software support the use of a camera?	This is highly desirable as one of the aims of the project eliminate the use of multiple forms of hardware.	Yes No	1 -1
SAP Integration	Does the software integrate with SAP.	This is a desirable criteria as this would allow instant updating of asset information within SAP and would allow for the expansion of condition assessments to include on the spot creation of planning items for future works.	Yes No	1 0
ESRI Integration	Does the software integrate with SAP.	This is a desirable criteria as this would allow seamless updating of asset information in SunWater's Corporate GIS Systems	Yes No	1 0
Both SAP/ESRI Integration	Does the software integrate with both ESRI and SAP.	This would be the most desirable outcome for a software package.	Yes No	3 0
Multiple Operating Systems	Does the software support multiple operating systems?	This is a benefit to SunWater as it means multiple devices are able to be used and the software coulb perhaps be adopted to hardware already owned by SunWater	Yes No	2 -1
Operating System	What operating system does the software support?	This is an important factor in terms of which hardware can be selected.	Operating System	N/A
Offline Data Recording	Does the software support offline data recording?	This is an essential criteria for SunWater as many of our Water Supply Schemes have little or no network coverage.	Yes No	1 -1
Navigation	Does the software support navigation?	This is a desirable criteria as condition assessments are often carried out in unfamiliar locations. This will also eliminate the need for hardcopy mapping.	Yes No	2 -1

3.0 CONDITION ASSESSMENT AND DATA CAPTURE

The following section looks at past articles that have been written relating to the process of mobile data capture development and implementation. In particular the review focuses on the varying mobile data capture systems in terms of mobile device, platform and software. The articles considered cover a range of industries, not just the water industry. Some of the research discussed below is from case study presentations that were carried out at the Field Service Management Summit 2013 which is an annual summit showcasing presentations relating to workforce mobility from leading Australian companies and utilities. The summit was particularly relevant as there were many utility companies describing their methods of mobile data capture integration, software, device, learnings and outcomes. The summit also featured leading data capture software companies and state of the art mobile devices which was particularly relevant to this thesis.

3.1 MANUAL CONDITION ASSESSMENT AND DATA CAPTURE

As described in Section 2.1 condition assessments within SunWater are currently carried out using a paper based, manual transcription approach which was initiated in the 1990s. "Although the usage of mobile technologies for IT management and improvement of business processes is far behind expectations, still little research has been done in analyzing critical success factors for mobile technology acceptance and usage when replacing a former paper-based process within the IT-Service domain." (Thurnher 2007). This will be a challenging factor for SunWater but it is hoped the implementation and examination of a trial system will help with these issues.

With the current advancements in technology and usability of mobile devices, Brisker states: "People are demanding the same social, intelligent technology that they enjoy in their personal lives make them more productive in their professional lives." This expectation is a driver for investigation into improvements and further development in the mobile field for SunWater.

3.2 MOBILE CONDITION ASSESSMENT AND DATA CAPTURE

Implementing a mobile data capture system to replace a manual process is not a straightforward task. The speed at which technology is moving makes it almost impossible to keep systems up to date or even predict where the technology will be heading in the future. With so much technology available, Wang (2005) discusses that the challenge for companies is not necessarily network integration or device management but how to instantiate available mobile technologies and form a business solution that is suitable to the organizational environment.

Energex (Stevens, D. 2013) found this to be the case when they implemented their own system. This company engaged a consultant to write software for a specific mobile device. At the time this system served its purpose and they were able to continue without any changes for 4 years. They have however come to a point where the device they have been using is out of date and no longer manufactured. Their devices are slowly failing and they are having to share between multiple people. This now means that a blanket system upgrade of software and device will be required.

3.2.1 The Device

One of the main points to consider when implementing a mobile data capture system is the type of device that will be used. This can be dependent of any number of factors. Will the device be used for indoor or outdoor inspections, is it likely to get wet or dirty, is it large enough for all users to read easily, can it be read in the sun, is it shock proof, does it need to be handheld or vehicle mounted etc.

Statistics from StatCounter Global Stats (Figure 3.1) show that between February 2012 – February 2013 over 60% of mobile operating systems in Australia were iOS (Apple). The latter portion of 2012 and commencement of 2013 shows a slight decline in the numbers for iOS systems and a slight increase in the Android operating system however it is clear that Apple are still a dominant force in the Australian mobile industry.

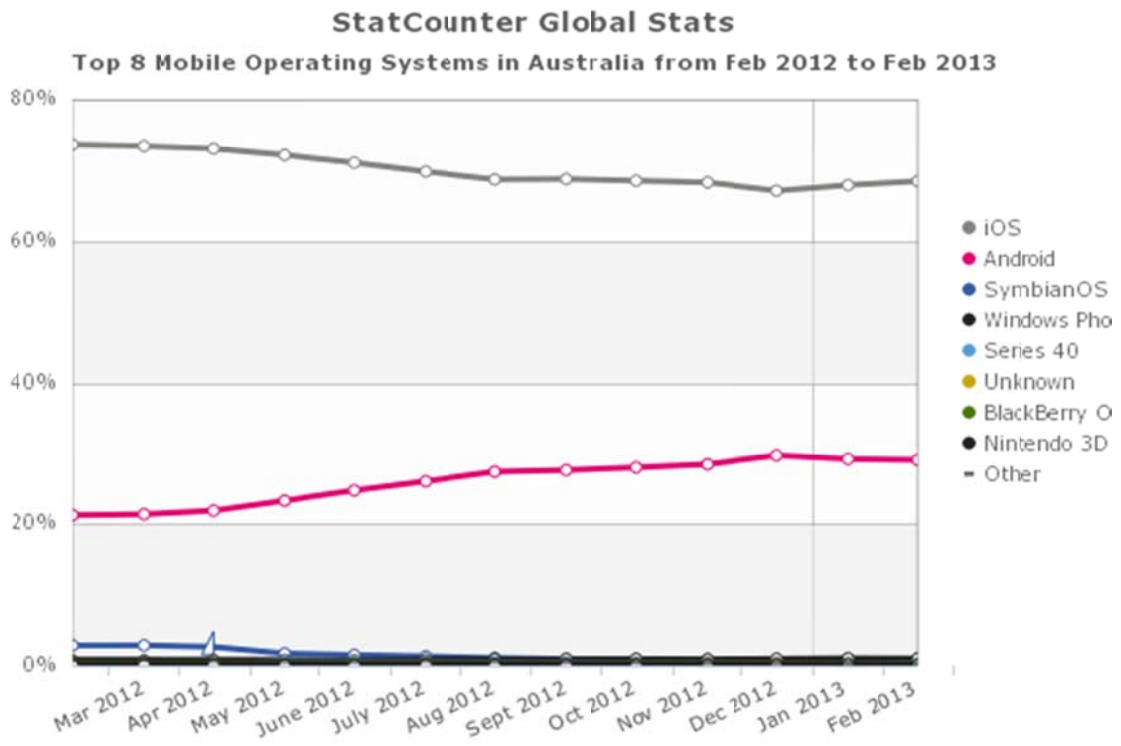


Figure 3.1 - Top 8 Mobile Operating Systems in Australia from Feb 2012 - Feb 2013 (Source StatCounter Global Stats)

This could be a possible influencing factor for SunWater when choosing a mobile device with which to carry out mobile data capture. At present SunWater is utilising Apple iOS mobile phones and tablets so the question of which device may require little investigation however there is of course the issue of whether a rugged device is required or whether ruggedized/waterproof enclosures would suffice.

There are such a multitude of devices in the market at the moment that it's almost impossible to select a device that is widely used and accepted in the industry when it comes to mobile data capture. For most companies it's a case of trial a number of devices and select the one that works best and is most cost effective.

The basic range of devices that are present in the market today are:

Smartphones – More and more people are adopting smartphones, tablets and other handheld devices for business and personal use (TOA Technologies 2012).

Figure 3.2 - Apple iPhone 5 Smartphone (Apple 2013)

Figure 3.3 - Samsung Galaxy S4 Smartphone (Samsung 2013)

Tablets – These devices are handheld touchscreen computers similar to iPad's, Samsung tablets, Windows Surface.

Figure 3.4 - Apple iPad Tablet (Apple 2013)

Figure 3.5 - Microsoft Surface Tablet (Microsoft 2013)

Figure 3.6 - Samsung Galaxy Note Tablet (Samsung 2013)

Rugged Tablets/Handhelds – These are rugged versions of tablets/handheld devices often with waterproof and dustproof enclosures and gorilla glass fronts to resist any sort of shock or rough treatment.

Figure 3.7 - Trimble Yuma Rugged Tablet (Trimble 2013)

Figure 3.8 - Motorola MC67 Mobile Computer (Motorola Solutions 2013)

Laptops – These have been around since the early 1980's and were the beginning of the mobile workforce.

Figure 3.9 - Dell Inspiron 17 Laptop (Dell 2013)

Rugged Laptops – Again these are just a rugged version of the laptop with sturdier enclosure and glass and are often mounted in vehicles.

Figure 3.10 - Panasonic Toughbook Rugged Laptop (Toughbook 2013)

Device Casing – Shock and waterproof cases can also be purchased for devices more susceptible to the elements making them more suitable for use in the field. Anti-glare screen guards can also be utilised for outdoor work.

For the specific role of carrying out condition assessments in SunWater it is likely that a mainstream mobile phone or tablet with ruggedized enclosure would be appropriate. The staff who carry out these condition assessments would be actively using these devices in the field for approximately 20% of the year. This would suggest that the larger capital outlay for a specifically ruggedized device would be unnecessary. The mainstream devices can also be used to remotely connect to SunWater's network enabling alternate business use such as checking emails, working on documents etc. This multi-use advantage makes the purchase of a ruggedized device solely for condition assessments unrealistic. A ruggedized device is also likely to be a bulky and cumbersome apparatus to carry in the field. As discussed by (Risk, K. Dalkia 2012) 'Ruggedized devices had been trialled in the past but tended to remain in the car or in the tool box - not always at hand.' Its hoped to avoid this scenario by selecting a device that staff will enjoy using.

APPENDIX E provides a comparison chart of the types of mobile devices that were investigated as part of this thesis. This provides a basis for the selection of a mobile device. Since the creation of this matrix however several of the devices have since been upgraded. This continual hardware upgrade is a point for consideration for organisations when looking towards a mobile data capture system. This matrix is also a guide and it's recommended that devices be trialled in the field before a decision is made on the final product. As discussed in Section 4.1 initial impressions of a device can change when it comes to actually using the device.

3.2.2 The Software

It has become evident from listening to and researching numerous case studies (see References) that there are a number of points for consideration before implementing a mobile data system.

The system needs to be able to work offline – It's evident from the Telstra Network Coverage map (Figure 3.11) that ubiquitous network coverage across Queensland is unrealistic at this point in time. For this very reason the mobile system needs to be able to work offline and re-sync when re-entering an area with network coverage. (Huff. K et al., 2000) discusses, "In mobile environments, constant connectivity is too strict a requirement. It is desirable to support a client-side activity execution mechanism for mobile workers to perform work activities in a disconnected mode." Even at this time it was evident that disconnected editing was essential for mobile workforce success.

Telstra states "Like any other mobile network, coverage on the Telstra Mobile Network depends on where you are, the mobile handset, tablet or broadband device you're using and whether it has an external antenna attached." There is the possibility of the inclusion of vehicle based antennae for these mobile devices however it is hoped that the inclusion of disconnected editing within the data collection software would negate the need for this extra expense.

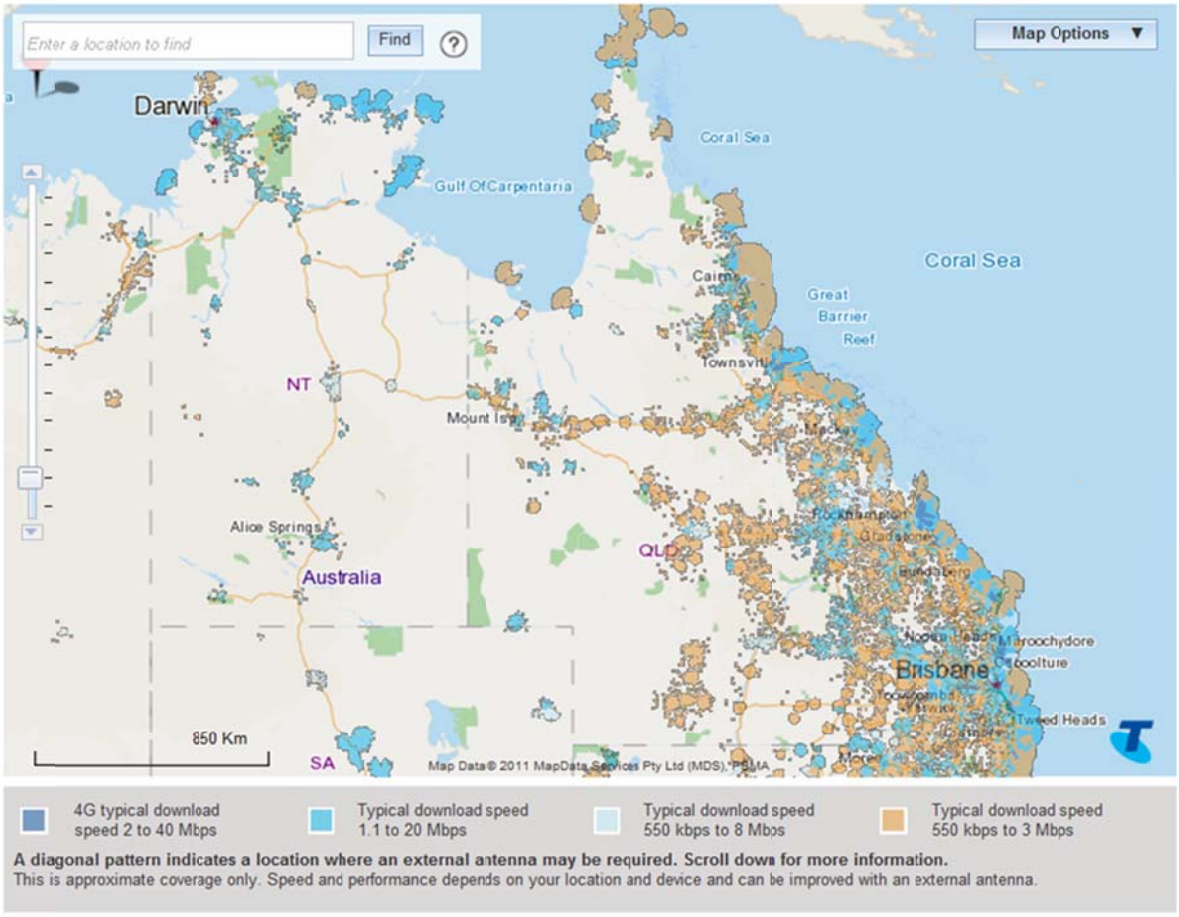


Figure 3.11 - Telstra Network Coverage in Queensland (Telstra 2013)

- No data loss – The system needs to be able to support a number of scenarios where data can be lost. The system will become less efficient than manual processes if it begins to lose data through coverage loss or device failure.
- The software should be platform independent (i.e will work on Android, Windows, iOS) – This criteria is more to satisfy the Bring Your Own Device (BYOD) scenario that is becoming more and more popular in the industry. Platform independent software reduces the likelihood that the system will need to be upgraded as regularly as a platform specific system.
- The system needs to be better than pen and paper - This is the crux of the mobile data capture problem. It can often be a costly task to create a system that ties into existing corporate software. This can mean that companies settle

for an application that is merely a replacement of pen and paper. For example the staff go into the field, record data on their device and then manually upload and sort the data in the office.

Currently both SAP and ESRI have off the shelf mobile applications that could possibly be suitable to carry out the tasks required for the condition assessment. As they stand neither solutions satisfy integration between the two software packages without expensive customisation. “Many advances have been observed in both fields but no direct integration was accomplished due to the complexity involved in handling each system.” (Abou-Ghanem, M. et al., 2008). The best option for SunWater in terms of trialling a mobile device is to utilise the ESRI application, ArcGIS mobile, as this provides integration into our corporate GIS systems and provides an easy upload solution into SAP. At this point in time the SAP applications do not appropriately communicate with the ESRI software.

3.3 ASSET MANAGEMENT

Asset Management is a necessary role in the business of managing assets and can be further described as Infrastructure Asset Management. Austroads 2009 describe Infrastructure Asset Management as:

"A systematic process of effectively maintaining, upgrading and operating assets, combining engineering principles with sound business practice and economic rationale, and providing the tools to facilitate a more organised and flexible approach to making decisions necessary to achieve the public's expectations."

This asset management function divests into asset management plans which in the case of SunWater involves the implementation of maintenance which is in turn scheduled on the basis of condition assessment of assets.

Geraerds (1985) defined maintenance as “all activities aimed at keeping an item in, or restoring it to, the physical state considered necessary for the fulfilment of its product

function."

Maintenance Engineering Society of Australia (MESA) recognises this same function as, "the engineering decisions and associated actions necessary and sufficient for the optimization of specified capability."

These engineering decisions and activities aimed at keeping an item fit for purpose are achieved by SunWater, in-part, through the use of condition assessments. Whilst these condition assessments and the process to undertake them currently fulfil their purpose, Jardine and Tsang (2006) state "the business imperative for organisations seeking to achieve performance excellence demand that these organisations continuously enhance their capability to create value for customers and improve the cost-effectiveness of their operations."

This supports the view that performance is achieved through the enhancement of processes and therefore encourages the possible implementation or investigation of a mobile data capture system in an effort to enhance and improve the cost effectiveness of operations.

3.4 SUMMARY

In order to provide a tactical and strategic direction for maintenance of SunWater's extensive infrastructure base asset management is necessary. If condition assessments are suitably completed as part of this asset management, scheduling and effective planning of asset maintenance can occur. This maintenance in turn will provide optimal asset performance and business operations for SunWater.

4.0 DEVELOPING THE MOBILE DATA CAPTURE TRIAL SYSTEM

Following the research discussed in Section 0 and utilising the project objectives to frame the methodology the following processes were carried out to develop the mobile data capture trial system.

4.1 THE DEVICE

Initially it was decided that the Trimble Yuma rugged tablet currently owned by SunWater would be used to carry out the trial as it was a Windows based device and would complement ArcGIS Mobile which is designed to run in a Windows operating environment.

After obtaining the Trimble device and attempting to carry out basic tasks within the office it became obvious that this was not the ideal solution for mobile data capture, even for a trial.

The device, which is now three to four years old, runs a Windows 7 operating environment on a seven inch screen with stylus. The difficulty that arose with this device was that selecting buttons and performing actions on such a small screen was quite difficult, even in an office based environment. The stylus is quite small with a very fine end which helps with the fine motor skills required however this type of delicate operation is not at all ideal in the field.

The decision to not proceed with the Trimble device was a difficult one as the selected software, ArcGIS Mobile, is windows based. Discussions with an ESRI employee about the situation revealed an alternative solution. This solution allowed for the use of mobile devices and tablets that were either Android or iOS based. As a result it was decided that a personal iPad would be utilised for the purposes of the trial.

The decision to use a mainstream mobile device has ensured that the trial will provide the user with an intuitive and easy to use interface with ample screen real estate. A

comparison between this device and other mobile capture instruments can be seen in APPENDIX E.

4.2 THE SOFTWARE

As discussed in Section 4.1 the decision to move away from utilising ESRI's ArcGIS Mobile software was due to the change in device. As a Windows based device was no longer being utilised and alternative software was required.

As mentioned previously discussions with an ESRI employee revealed another arrangement that could be utilised for the trial. This alternative is the Collector App. The Collector App can operate on an iOS or Android system and provides an adequate solution for the trial.

When comparing the Collector App to the other software that was investigated it is apparent that the current version doesn't meet all the criteria that are desirable (See APPENDIX F). At present the application does not support disconnected editing, it does not have a standalone iPad version (however the iPhone App can be used on the iPad) and it does not integrate with SAP. ESRI however are due to release in late October 2013, the Collector App v10.2. This upgrade will include a standalone iPad version of the application (ArcGIS Resources 2013). Despite the limitations of the current application it has provided adequate basis for completion of a trial mobile data capture system.

The Collector App works through an ArcGIS Online account. Organizations with desktop licenses of ESRI ArcMap are automatically assigned ArcGIS logins for each license they have purchased. Unfortunately for the purposes of this trial the ArcGIS Online subscriptions have not yet been released for SunWater so a 30 day trial account was utilised. This trial account provided the full functionality of a registered ArcGIS Online login.

4.3 DATA DEVELOPMENT AND QUALITY CONTROL

In the initial stages of the project it was realised that there was a need for data correlation between our SAP asset register and our Corporate GIS systems. For the purposes of the trial a data dump was taken from SAP that listed every asset relevant to Irrigation and Drainage in the Burdekin Haughton Water Supply Scheme (BHWSS). This formed the point of truth for the number of assets required for assessment.

In order to successfully incorporate this data with the Collector App, each asset needed a geographical location. SunWater already houses a comprehensive database of geospatial information related to its assets however due to the age of this data and SunWater's ever evolving asset base, approximately 60% of the assets have linked geographical locations.

In order to rectify this situation an overhaul of the Corporate GIS data was required for the BHWSS. This involved exporting the attributes from our BHWSS_Assets featureclass in ESRI to create an excel spreadsheet that was linkable with the asset data dump from SAP.

The unique identifier between both GIS and SAP was the asset's Object Number. This is always the point of truth for linkages between separate asset data sources. SunWater's assets have additional naming conventions that often evolve and are upgraded however fortunately the Object Number always remains the point of truth.

As mentioned previously this link provided about a 60% success rate leaving 40% of the assets without a geographical location. This failure to link or missing data can also be due to the structure and sub-structure of assets within SAP.

SunWater's assets are broken down into a tiered type arrangement where there is a header, a structure and then sub-components of that structure. Each of these tiers have Object Numbers. For example a regulator gate may be broken down as shown:

Regulator Gate – HEADER

Concrete Structure – STRUCTURE

Safety Screen – SUB COMPONENT

Depending on how this asset was initially located in GIS its likely that only one component of the regulator gate was recorded. This is problematic as each component of that structure needs to be assessed and often each component will have different assessment intervals. For example the metal safety screen will need to be assessed at more regular intervals than the concrete structure.

When condition assessing is carried out it is desirable that each component has a geographical location. If only the header has a location this leads to a very time consuming process to search through each asset, determine its header and hence determine its geographical location. This is one of the reasons that providing geographical locations for condition assessments at present is so time consuming.

In order to rectify this in the BHWSS data a visual inspection of the spread sheet data could quickly be made to determine which assets could be linked together to share the same coordinates. This process meant that approximately 80% of the assets had geographical locations.

Finally the distance data provided in SAP allowed for a geoprocessing solution in ArcMap to locate the remaining assets. This meant that a specific tool in ArcMap, namely 'Locate Route Events' could be used to locate these missing assets along SunWater channel centrelines using the distances recorded in SAP as locators. This process resulted in 90% of the assets having geographical locations. The remaining 10% were unable to be located due to missing data in SAP and would require individual research and exploration of design drawings to determine their location. This would be a time consuming process and was not necessary for this trial.

Evidently while this project has been in progress an upgrade of the condition assessment methodology of assets in SAP (the BILL project) has been carried out. This change has impacted the BHWSS data significantly and would need to be rectified

if SunWater decided to proceed with a mobile data capture system. For the purposes of the trial however the data will remain as is.

4.4 ARCMAP – SETTING DOMAINS AND SUBTYPES

With the development of a strong asset database in the BHWSS it was possible to start experimenting with the Collector App and determining how it would be arranged to carry out these assessments. Despite utilisation of existing software much research was carried out to determine the best practice methods of data arrangement and upload. The main documents utilised for this research were Collector for iOS ArcGIS Help 10.2 within ArcGIS Resources.

Figure 2.2 shows an example of the condition assessment form that is currently used to record assessments. This form needed to be available electronically on the iOS device. This is where the Collector App would be utilised.

Each asset is grouped into a condition assessment (CAP) type which determines what sort of condition assessment form the asset requires. These forms have specific criteria that relate to particular assets. As a result the application needed to be able to interpret the CAP Type for the asset and return the specific criteria required for that asset.

ESRI's ArcMap provided a solution for this. ArcMap enables the user to create Domains and Subtypes within the attribute data of a point. At this stage what was available was a point featureclass containing 90% of the Irrigation and Drainage assets in the BHWSS. These points are linked with the data that was extracted from SAP. Within this SAP data is the CAP Type for each asset.

The first step was to create a subtype that included every CAP Type present in the BHWSS data. This numbered 34 different options (see APPENDIX H). The second step was to create links that would represent the different assessment categories for each asset. For each asset there are six different categories, this resulted in over 200 linkages. These links needed to be automatically recalled so that they defaulted to the correct criteria when a certain CAP Type was selected.

In order to achieve this a process was used that was similar in concept to the IF statement in excel. For example if the CAP Type 'XDRN' is selected then the six categories appropriate to 'XDRN' would appear. The default values for each CAP Type were defined in ArcMap and tested.

The next process was to create a domain to enable a drop down list to select a rating for each criteria. The ratings available range from 1 to 6 and each of these ratings incorporate a specific description to help the user determine which is appropriate. As there are over 200 criteria and there are a possible 6 ratings that can be chosen for each criteria this resulted in over 1200 unique ratings that were required, an example of which you can see in APPENDIX H. Each set of six ratings were programmed so that they defaulted to their correct criteria.

Finally a comments field was incorporated for each criteria to allow for extra notes. Discussions with staff within Irrigation and Drainage have noted that it could be helpful to include a list of standard comments that the user could choose from. This will be considered and staff will be asked for their input in this area.

This was a time consuming and complex process however now that the framework is established this will be able to be transferred to different water supply scheme data.

4.5 THE COLLECTOR APP

Now that the framework and behaviour of the featureclass has been established in ArcMap it is possible to publish this service to ArcGIS Online and ultimately the Collector App. This can be simply done by logging into your ArcGIS Online account within ArcMap and publishing a feature service to ArcGIS Online. Once this process has been carried out the user can log in to ArcGIS Online on a desktop and view the map and data that was published enabling for any further editing or customisation that is required. ArcGIS Online is also the place where privacy settings for maps and data are recorded.

Maps created for ArcGIS Online can be kept private, shared within an organisation (i.e. SunWater) or shared with the public. Permissions can also be set on the map to enable or disable editing capabilities.

In order to view this information on the iPad the Collector App must first be installed. This is a simple process of going through the App Store on the iPad and downloading the free Collector App application. When this is performed on an iOS device an Apple ID is required for download. It is expected that each user of the mobile device would have their own work related Apple ID. Similarly a Google Play account is required for an Android device.

4.6 CUSTOMISATION

Further customisation of the app is available once the data has been published to ArcGIS Online. Pop-up windows are available and are the resource through which users complete the condition assessments. These pop-up windows can be configured so that only certain data is available and can be edited. For the purposes of the trial the popup was customised so that only certain informational attribute fields such as 'Object Number', 'Asset Description', 'Object Type' and 'Channel Name/Distance' were able to be viewed. The window was also customised so that fields related to the condition assessment process could be seen and edited. This customisation cut down on superfluous data being shown and confusing the assessor. Only information relative to the condition assessment process and the identification of assets was present. Figure 4.1 below shows a screen shot of this pop-up and the information present.

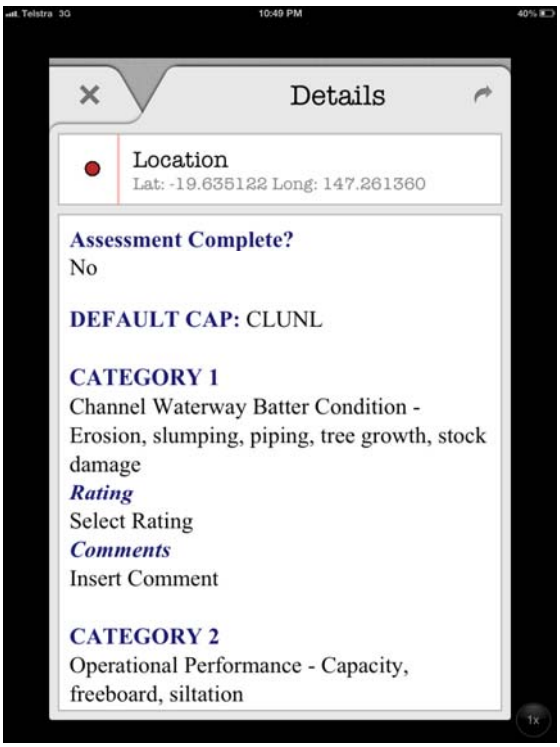


Figure 4.1 - Customised Pop-Up Window in Collector App

This window is scrollable and houses all six categories relevant to the selected asset.

4.7 THE TRIAL

In September 2013 a trial of the prototype system was carried out in the Barratta Section of the BHWSS. The trial was completed over a half day and due to time constraints was unable to extend beyond this. APPENDIX I shows a map of the site and the assets which were selected for assessment.

The trial involved the new mobile data capture process and followed the procedures as shown in Figure 4.2.

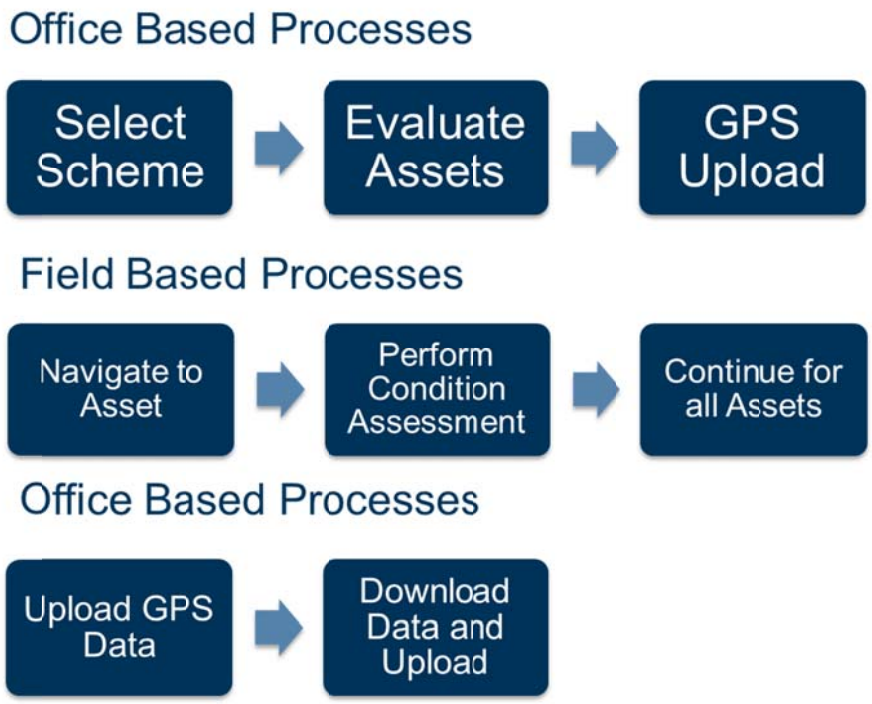


Figure 4.2 - The Mobile Data Capture Process

The trial was essential broken down into three components, these being: Preparation, Condition Assessment and Post Processing. These are the three core components of the condition assessment process and make analysis of data more convenient.

4.7.1 PREPARATION

A list of assets was selected from SAP for assessment based on the criteria mentioned in Section 2.2.2. It was decided to target the drainage assets in the Barratta area as these are notoriously difficult to locate. This list of assets was then linked to the updated GIS data. There were 5 sites out of 150 that were unable to be automatically linked hence these were located within ArcMap utilising structure distances and channel centrelines. This will be a typical stumbling block with SunWater's GIS information and it is assumed that even with an upgrade in the data there will be case by case incidences where assets will need to be manually located for upload.

4.7.2 CONDITION ASSESSMENT

Before the trial a risk assessment was carried out in order to mitigate the risk involved in completing a field trial condition assessment. The risk assessment format adopted follows the standard SunWater Safe Work Method Statement (SWMS) and can be seen in APPENDIX J.

The location of the assets was relatively close to the SunWater office and travel time was negligible. Navigation to the first site for assessment was carried out using the Collector App's navigation resources. Once the site was located an assessment was carried out by a colleague utilising the appropriate condition assessment manual. This assessment was then recorded via the collector app against the correct asset. This assessment was then saved and sent back to the ArcGIS Online server. Navigation to and assessment of a further 19 sites was carried out.

4.7.3 POST PROCESSING

Once back in the office the condition assessment data was downloaded from the ArcGIS Online server and loaded into ArcMap. This updated assessment data was then extracted from ArcMap and copied into the upload spread sheet for upload to SAP. The data however was not uploaded into SAP due to the nature of the trial.

4.8 COSTING OF EXISTING PROCESSES

In order to accurately compare the manual and mobile processes performed in the condition assessment process, information must be obtained relating to the current condition assessments. The staff of the Irrigation and Drainage Department within SunWater charge the time for their condition assessments to a set of codes appropriate to each water supply scheme. Any time spent in preparation, condition assessment and post processing is charged to these codes. For the purposes of this thesis it was decided to focus on the time charged to the condition assessments performed in 2013. This ensures the current condition assessment processes are being examined. This data was obtained prior to the trial and updated as more information became available.

This information helped to provide a benchmark during the trial and give an indication on the performance of the system.

5.0 RESULTS AND RECOMMENDATIONS

There are a number of results that are important to review when considering a mobile data capture system. The following section will discuss the outcomes of the trial and any of these relevant results.

5.1 QUANTITATIVE RESULTS

As mentioned previously the trial was completed in three sections. There was the Preparation of the data, the Condition Assessment and the Post Processing of the data. In order to determine how the trial processes fared in comparison to SunWater's manual condition assessment processes, Figure 5.1 depicts a percentage breakdown of tasks from this year's condition assessments and the trial.

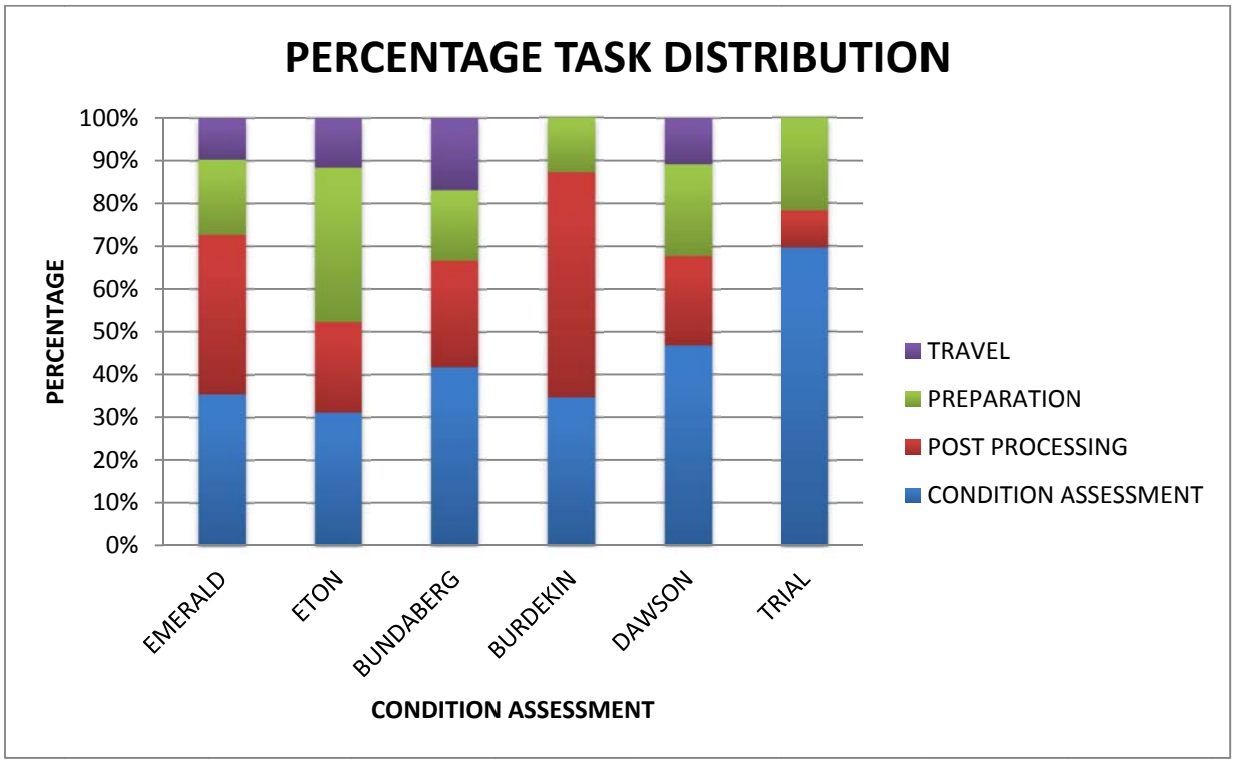


Figure 5.1 – Percentage Task Distribution

It can be seen in the assessments other than the trial that the Preparation and Post Processing take up a considerable percentage of the time spent on condition

assessments. In some cases this percentage is greater even than the time spent doing the actual condition assessments. A breakdown of these percentages can be seen in Table 5.1 below.

Table 5.1 - Percentage Breakdown of Condition Assessment Tasks

	CONDITION ASSESSMENT	POST PROCESSING	PREPARATION	TRAVEL
EMERALD	35.4%	37.3%	17.6%	9.7%
ETON	31.2%	21.1%	36.2%	11.6%
BUNDABERG	41.6%	25.1%	16.5%	16.8%
BURDEKIN	34.6%	52.6%	12.8%	0.0%
DAWSON	46.8%	21.0%	21.5%	10.8%
TRIAL	69.6%	8.7%	21.7%	0.0%

The trial data shows a dramatic decrease in the time spent during Post Processing however the Preparation time remains relatively similar to the other assessments. In comparison to the other assessments the trial was quite short hence the Preparation percentages are not showing a dramatic decrease. If the trial were extended to a full 30 hour assessment this Preparation time would remain the same as the number of assets prepared was equal to a full condition assessment. This being the case a full trial would show improved Preparation percentages as well as Post Processing.

These improvements in Preparation and Post Processing are likely to be the major cost saving for SunWater if a mobile data capture system is adopted. From the data that has

been collated a possible 30% decrease could be expected with the adopted of the trial system.

One of the other areas it was hoped that the mobile data capture system would also improve was navigation. Quite often assets are assessed within SunWater that are difficult to locate. Many of our assessments are also carried out in unfamiliar locations hence navigation is more difficult in some areas than others.

From the trial it was found that the usually difficult to find assets such as Protection Works on drains were able to be quickly and easily located using the iPad in conjunction with Collector App. This was a positive result and it's expected that some of the more difficult areas will have improved navigation times.

Figure 5.2 below shows the average minutes per asset assessment from this year's condition assessments and the trial. Irrigation and Drainage generally plan their assessments using a 12 minute per structure assessment time which is approximately 50 asset assessments per day.

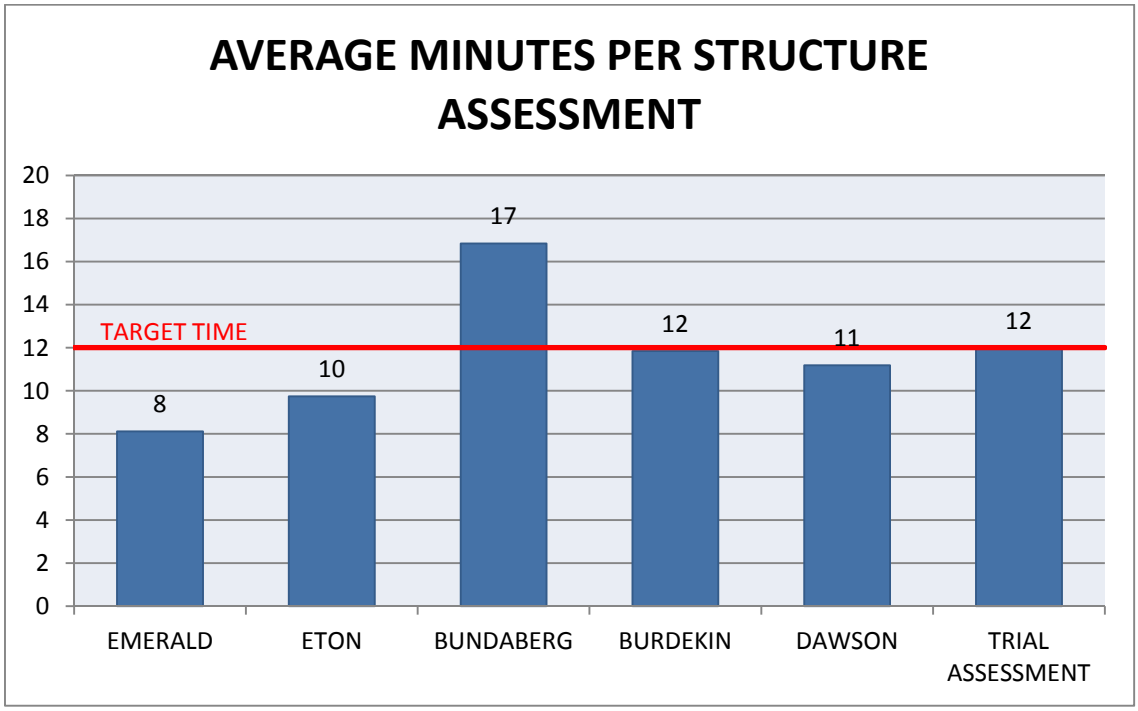


Figure 5.2 - Average Minutes per Structure Assessment

As you can see from the graph the trial assessment was equivalent to the current assessment target of 12 minutes per asset assessment. It can be seen that both Emerald and Eton are well under the 12 minute target. This is possibly due to the type of assets that were assessed. In some cases only the assets that can be easily found will take preference over those that are more difficult hence cutting navigation and assessment times to a minimum. The size and age of the scheme also play a large part in the ease of navigation. This time difference could also be due to the use of different assessors for different areas.

From this graph it is evident that there are unlikely to be any real time savings in navigation except perhaps in the Bundaberg region which was quite a bit slower than the other areas. Unfortunately there is not yet data available for the Mareeba region however it is expected that the navigation improvements of the Collector App would be of use in this area due to the age of the system, the type of assets which need to be assessed and the ease of access/location of the structures (i.e. inhibition from long grass).

5.2 DEVICE PERFORMANCE TRIAL RESULTS

Aside from the improvements in assessment and processing times it is necessary to review the performance of the device that was used during the trial. The Apple iPad.

Use of the device within an office environment is quite efficient, intuitive and easy to navigate. Some issues did however arise when this device was used in the field.

Initially during the trial the iPad was taken outside of the vehicle to perform the condition assessments. It became apparent however that this method of assessment was not going to be appropriate with the iPad as the screen visibility was almost zero in sunlight. As a result of this finding it was decided that one person would perform the condition assessment outside the vehicle and one would remain inside the vehicle with the iPad recording the assessment. This process worked well and is essentially what already happens during the current condition assessment process.

Another issue that occurred during the assessment process was that the iPad froze during recording. This was easily solved by turning the iPad on and off and may have been attributed to the hot conditions on the day. This did however bring to light the issue that should the iPad fail in the field there are no other methods of continuing to record assessments. One possible safeguard would be if the two assessors both had either apple or android smartphones as their designated work phones. This would mean assessments would be able to continue to be made on alternate devices.

During the trial the iPad that was used did not have any form of ruggedized casing. This is an element that would need to be included on any device that is selected to perform mobile data capture in the field. The dusty and also wet conditions that are present make it imperative. General wear and tear would also be reduced with one of these cases.

5.3 SOFTWARE PERFORMANCE TRIAL RESULTS

As has been discussed ESRI's Collector App was utilised for performing the trial condition assessment. Overall this application performed quite effectively.

Preparation of GIS data within ArcMap and then transfer to the ArcGIS Online account is quite efficient. The process utilises software that SunWater staff are already familiar with hence no extra training is required. The upload and download of data are efficient and the time for download of condition assessments doesn't differ in terms of asset number. This is because all asset information is downloaded regardless of whether an assessment was performed or not. Therefore a download for one assessment would take a similar amount of time to that of 50 assessments. This is where the time savings are made.

The Collector App interface is generally easy to navigate. There are few screens and options making processes quite simple and easy to follow. The navigation feature of the application is adequate however does not perform as well as navigation alternatives such as Google Earth.

Recording of condition assessments is quite simple however there is no improvement in the time it takes to record these assessments. In fact it does appear to be more convenient to simply transcribe these assessments on paper. The aim of this process however is to reduce pre and post processing times which the application does effectively do.

The version of Collector App that was used for the trial was 10.1. This version is a smartphone specific release hence viewing of the application on the iPad was not as effective as it could be however it was sufficient for the trial.

Version 10.1 also does not support disconnected editing of data. This is essential for SunWater due to the locations of our assets and marginal network coverage. The release of Collector App version 10.2 is set to be late October 2013. This version is stated to include support for tablets however inclusion of disconnected editing will not be available until version 10.2.1 in early 2014 (ArcGIS Resources 2013).

5.4 HARDWARE RANKING RESULTS

As discussed in Section 2.3.2 an investigation of the types of hardware available for mobile data capture was carried out. This hardware was assessed against a set of requirements relevant to SunWater. The process undertaken when assessing this hardware was discussed in Section 2.3.2.

The outcome of this assessment can be seen in Table 5.2 below.

Table 5.2 - Hardware Ranking Results

HARDWARE	SCORE
Toughpad FZ-A1	19
Toughpad JT-B1	19
iPad Mini	18
Yuma	18
Yuma 2	18
iPad (Retina)	17
iPhone 5	17
Samsung Galaxy S4 Active	17

BlackBerry Z10	14
Toughpad FZ-G1	14
HTC One	13
MC67	13
Samsung Galaxy Tab 3	10
ET1	10
Windows Surface	6

As you can see according to the ranking system that was developed, the Panasonic Toughpads have been evaluated as being most suitable for the function of performing mobile condition assessments in the field. An interesting result is that the two Trimble Yuma tablets have resulted in quite a high ranking also. As discussed in Section 4.1 it was noted that the Trimble Yuma tablet would not be suitable for use in the field due to its small screen and difficulties navigating with the stylus. It is difficult to evaluate criteria based on ease of use of the hardware without trialling the actual device first. Therefore it is recommended that selection of any hardware be ratified by first trialling the device and determining its suitability for use in the field.

5.5 SOFTWARE RANKING RESULTS

As with the hardware a software evaluation was also carried out and the process is discussed in Section Software Ranking2.3.3.

The outcome of the assessment can be seen in Table 5.3.

Table 5.3 - Software Ranking Results

SOFTWARE	SCORE
Collector App V10.2.1	10
Collector App V10.1	7
ArcGIS Mobile 10	4
Celstra In-field Inspections	4
Data Collection Application	3
Trimble Field Inspector	1
Sap Work Manager Mobile	1
SAP Rounds Manager	-3

The evaluation process shows an overwhelming outcome for the Collector App V10.2.1. This result is evident of the features that the Collector App V10.2.1 supports. The software that was utilised for the trial was the Collector App V10.1. At present this version of the app does not support disconnected editing hence the result of a lower score than the Collector App V10.2.1.

Although the evaluation process ranks this software on criteria that are suitable for SunWater, as with the hardware results it is difficult to make a final decision on the product without first performing a trial. It is recommended that before any software is selected for mobile data capture a trial of this software is carried out to ascertain its suitability and ease of use.

6.0 CONCLUSIONS

6.1 INTRODUCTION

SunWater do and will continue to perform condition assessments on the assets that it owns and maintains. While this need exists so remains the issue of finding an efficient means of completing these assessments.

6.2 CONSEQUENTIAL EFFECTS

The desired outcome of this project is that a decision will be reached as to whether or not SunWater should pursue the implementation of a mobile data capture system for condition assessment of assets.

A positive outcome from this dissertation may result in SunWater's adoption of the system used within the trial to commercially conduct condition assessments not only within the Irrigation and Drainage Group but across all departments in SunWater. This will result in numerous benefits for SunWater.

Environmentally this will mean the elimination of paper waste when carrying out condition assessments which will be quite a significant environmental milestone. At present there are usually around 6 condition assessments carried out during a year with approximately 1000 assets or more to assess. Currently each of these assets needs a paper form and a set of maps per scheme. When this is extrapolated across all departments of SunWater this has a considerable environmental impact.

Should the use of this system improve field capture efficiency then SunWater will be reducing the amount of fuel used per asset to assess so could potentially cover more assets in a shorter time or simply conduct smaller condition assessments. The assessment of more assets will ensure SunWater's data systems are kept up to date and accurate information is available for use in asset management and design.

A positive outcome will ultimately result in time and money savings, environmental benefits, staff efficiency improvements and will help to achieve improved productivity across the board.

A possible fallback to the successful adoption of a data capture system is that electronic devices are not likely to last long periods of time and are outdated almost every year. This could possibly lead to increased hardware wastage however it is expected that SunWater would adopt appropriate recycling strategies and would continue to comply with their 3 year upgrade of technological hardware policy.

Ethically this is a project that aims to improve the efficiency of a company and improve the accuracy of its data. It has environmental benefits and could be a significant improvement to SunWater's processes.

6.3 CONCLUSIONS

The purpose of this research paper was to determine two things: Whether the implementation of a mobile data capture system was an avenue of possible pursuit for SunWater; and whether the prototype system that was developed could be utilised by SunWater and if not what are the alternatives?

6.3.1 Is Mobile Data Capture a Possibility?

In terms of the research undertaken and trial performed as part of this thesis it seems evident that mobile data capture is an avenue worth pursuing for SunWater. The sheer number of assets that SunWater is required to assess is basis alone for investigating mobile data capture and the efficiencies it provides.

Recent developments relating to recommendations from the Queensland Government may result in SunWater owning only its headworks and associated infrastructure. This eventuality will mean there is a significant decrease in the amount of condition assessments SunWater is required to undertake. This may or may not negate the need for mobile data capture. At present however SunWater still maintains ownership of its

irrigation, drainage, pump and pipeline assets and based on current asset numbers would benefit from mobile data capture.

6.3.2 Is the Prototype System Acceptable?

The prototype system performed well in the field and in terms of the software is a logical choice for SunWater. This system utilises software that SunWater currently owns and staff are familiar with. Results from the software evaluation show that the Collector App V10.1 is a suitable solution for SunWater (Refer Table 5.3). The software performed well in the field and adequately performed the tasks required.

The device performed well also however anti-glare measures need to be investigated if this device is to be used in the field. In comparison to the other hardware that was evaluated (Refer Table 5.2) the Apple iPad was ranked relatively well. It was discussed in the results that the Trimble Yuma devices were not suitable hence ranking the iPad as equal second. There are alternative iOS and Android devices available that may provide a more appropriate field solution. If an iOS or Android solution can't be determined then alternative software may have to be considered to enable assessments to be performed on Windows or alternative operating systems.

Overall there is the possibility for a 30% reduction in post processing times using the prototype system. There is also the possibility of improved navigation times in the Bundaberg and Mareeba areas based off the results presented in Figure 5.2. These positive outcomes result in a positive outlook for mobile data capture within SunWater.

6.4 FURTHER WORK

To provide sufficient evidence and build a business case supporting the use of mobile data capture within SunWater an extensive trial of the prototype system needs to be performed.

At present there is not enough trial data to confidently recommend mobile data capture as an effective solution to SunWater management. It is recommended that a three day

condition assessment be performed with the trial system and that perhaps alternative hardware should be investigated and compared during this trial.

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APPENDIX A

PROJECT SPECIFICATION

University of Southern Queensland

FACULTY OF ENGINEERING AND SURVEYING

ENG4111/4112 Research Project

PROJECT SPECIFICATION

FOR:	Fiona Nielson
TOPIC:	Development and Evaluation of Field Mobility Data Capture System for Asset Condition Assessment
SUPERVISORS:	Dr Alexander Kist, University of Southern Queensland
	Peter Marshall, Senior Engineer Irrigation and Drainage, SunWater
ENROLMENT:	ENG4111 – S1, 2013
	ENG4112 – S2, 2013
SPONSERSHIP:	SunWater
PROJECT AIM:	This project will investigate and design a prototype field mobility system with the intention of increasing asset data capture and analysis efficiency in the field. As time permits, the recommended platform will be subject to rigorous cost benefit analysis and potentially the development of a business case.

PROGRAMME: Issue C, 18 April 2013

1) Undertake a basic requirements analysis, identify use cases and develop a platform functional specification:

2) Undertake a comprehensive literature review covering but not limited to the following aspects:

- The range of commercially available field mobility solutions:
- Industry user types, market requirements and directions;
- Types of software available, trends and support prospects;
- Types of hardware (i.e. tablet, phone. other), functionality and design obsolescence; and
- Advantages/Disadvantages of software/hardware/field data capture packages.

3) Develop an optimised prototype system incorporating a software solution/hardware package that satisfies SunWater's functional requirements. Engage the services of a third party to develop software/hardware solutions as required.

4) Develop and implement a test plan for developed software and hardware component. Undertake field trials and review performance against functional requirements;

5) Prepare and an academic dissertation of the research project;

As time permits

6) Analyse and evaluate business processes in relation to the developed system.

7) Undertake cost/benefit analysis of implementing the field mobility solution in the context of asset data capture and analysis;

8) Subject to positive outcome of point 7), prepare a draft business case for the implementation of the system within SunWater asset management; and

9) Provide recommendations on the implementation of the system and the final functional and technical specifications.

APPENDIX B

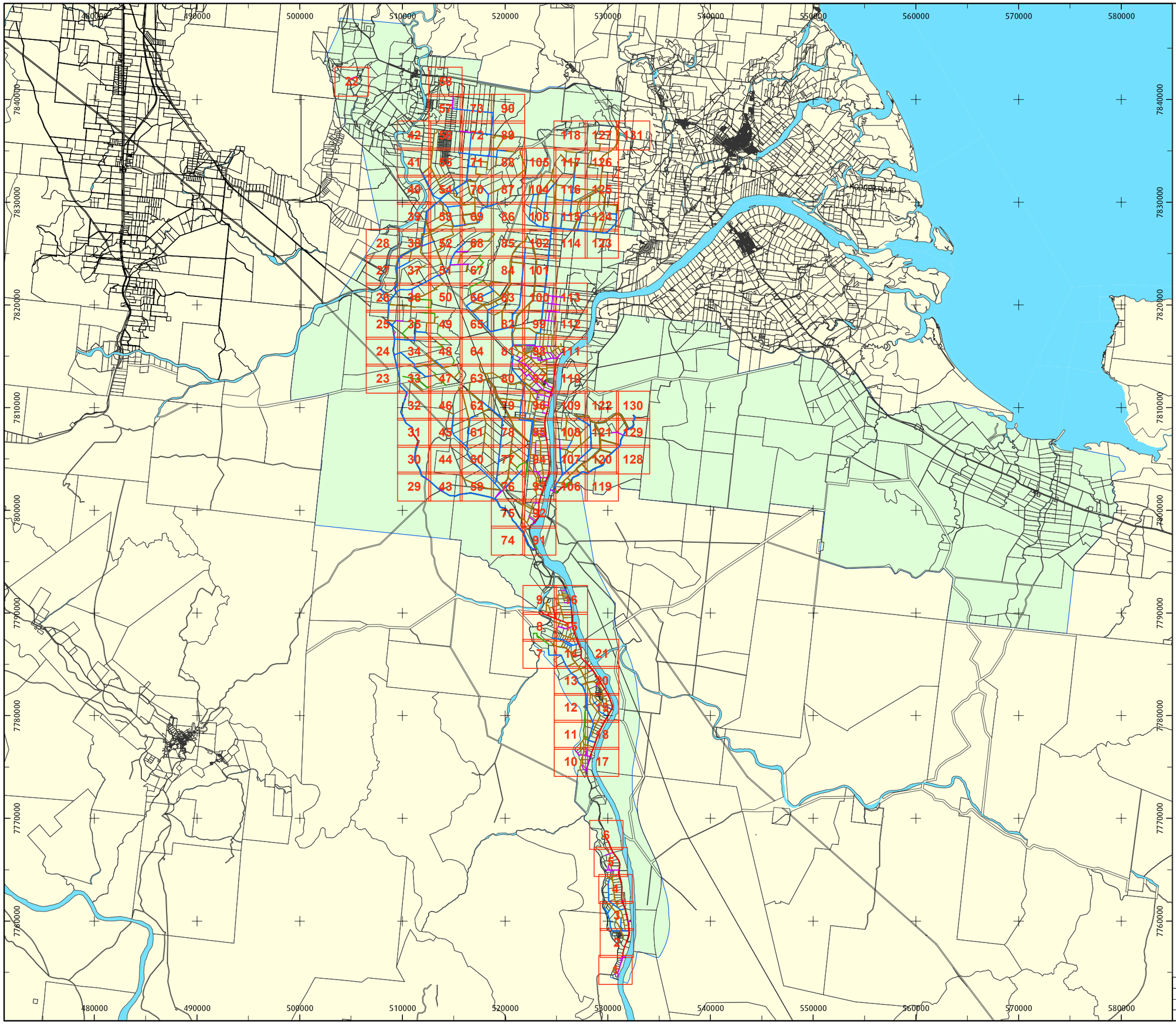
SCHEME KEY MAP AND EXAMPLE SHEET MAP FOR BHWSS

Document: G:\GIS_Data\corporate_data\burdekin\drawings\arcinfo\scheme-assets-keymap.mxd
Printed: Saturday, July 19 2003 12:35:44 PM

PRELIMINARY PLAN

SunWater Internal Document

Map Produced By:
SunWater, Engineering Services
PMB 5013, Ayr, QLD, 4807
Ph. 47830555, Fax 47836372



LEGEND

- Burdekin Irrigation Area

Asset Location Plan

- Sheet Number

SunWater Infrastructure

- Earth Channel
- Concrete Lined Channel
- Plastic Lined Channel
- Pipeline / Siphon
- Earth Drain
- Levee / Embankment

NOTES

1. Digital Cadastral Database(DCDB) information current at May 2003.

MAP INFORMATION

Black tics indicate 10,000m intervals of the Universal Transverse Mercator Grid, Zone 55 (Mapping Grid of Australia, MGA94). Coordinate System: Geocentric Datum of Australia (GDA94).

Scale 1:350,000 (before reduction A3)

0 1.5 3 6 9 12 15 km

BURDEKIN HAUGHTON WATER SUPPLY SCHEME

ASSET LOCATION PLAN KEYMAP JULY 2003

SunWater

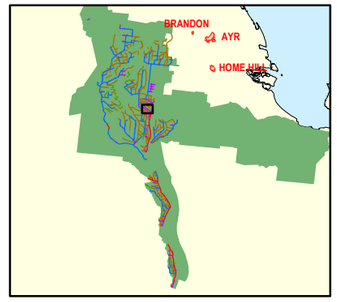
Engineering Services
www.sunwater.com.au

Prepared	*IDH*	Checked		Approved	
Revision	Date	Remarks			
Drawing Number		A3-??????			

Document: G:\GIS_Data\corporate_data\burdekin\drawings\arcinfo\scheme-assets.mxd
Printed: Saturday, July 19 2003 02:31:16 PM

Map Produced By:
SunWater, Engineering Services
PMB 5013, Ayr, QLD, 4807
Ph. 47830555, Fax 47836372

PRELIMINARY PLAN
SunWater Internal Document



OVERVIEW MAP

LEGEND

- Pump Station

SunWater Infrastructure

- Access Crossing
- Air Vent / Valve
- Channel Structure
- Check Structure / Regulator
- Cross Drainage Culvert
- Drainage Inlet
- Flowmeter
- Foot Bridge
- Isolating Valve
- Manhole
- Meter Outlet
- Rock Drop / Drain Protection
- Scour Outlet
- Siphon

SunWater Infrastructure

- Earth Channel
- Concrete Lined Channel
- Plastic Lined Channel
- Pipelines / Siphon
- Rising Main
- Earth Drain
- Levee / Embankment

NOTES

1. Digital Cadastral Database(DCDB) information current at May 2003.
2. Asset positions have been determined using a distance field stored in SunWater's Asset Register.

MAP INFORMATION

Black tics indicate 500m intervals of the Universal Transverse Mercator Grid, Zone 55 (Mapping Grid of Australia, MGA94). Coordinate System: Geocentric Datum of Australia (GDA94).

SCALE 1:10 000 (Before Reduction A3)

0 50 100 200 300 400 500 m

BURDEKIN HAUGHTON WATER SUPPLY SCHEME

ASSET LOCATION PLAN JULY 2003

SHEET 97 OF 131

SunWater
Engineering Services
www.sunwater.com.au

Prepared	*IDH*	Checked		Approved	
Revision	Date	Remarks			
Drawing Number	A3-??????				

APPENDIX C

SAP UPLOAD FORMAT FOR CONDITION ASSESSMENT DATA

Condition Assessment Upload

Copy from Condition and Risk Analysis Report (ZRMS_CAR3)
Mandatory Fields

Object No	Equip No	Functional Location	Description	Default CAP Type	CA Type	Assess Type	Assessor	Date (dd/mm/yyyy)	CA Score	Rem Life	Crit 1	Crit 2	Crit 3	Crit 4	Crit 5	Crit 6	Notes	Environ Notes	WH&S Notes	Maint Notes	Comments 1	Comments 2	Comments 3	Comments 4	Comments 5	Comments 6
IE0000000000010000044	10000044	AWC-PSTNA-PUN1-MTOR	MOTOR 11KV	MTOR	MTOR	Field	Andrew Boath	9/12/2009	4	10	4	4	4	4	4	4										
IF?0100000000000050240		AWC-PSTNA-PUN1-LFP	LINE FILLING PUMP	PUMP	PUMP	Field	Andrew Boath	9/12/2009	2	8	2	2	2	2	2	2										

APPENDIX D

CONDITION ASSESSMENT COST BREAKDOWN

Sum of Total Cost (Fiscal Year)	Column Labels				
Row Labels	**CONDITION ASSESSMENT**	**POST PROCESSING**	**PREPARATION**	**TRAVEL**	**GRAND TOTAL**
EMERALD - ASSET COND INSPECTIONS AM I&D	$6,141.80	$6,464.60	$3,048.00	$1,685.40	$17,339.80
ETON - ASSET COND INSPECTIONS AM I&D	$3,556.80	$2,404.80	$4,127.30	$1,322.18	$11,411.08
BUNDABERG -ASSET COND INSPECTIONS AM I&D	$5,606.00	$3,383.60	$2,219.40	$2,266.36	$13,475.36
BURDEKIN - ASSET COND INSPECTIONS AM I&D	$4,002.20	$6,078.80	$1,474.00	$0.00	$11,555.00
DAWSON - ASSET COND INSPECTIONS AM I&D	$6,115.80	$2,749.00	$2,806.80	$1,409.33	$13,080.93
LOWER MARY-ASSET COND INSPECTIONS AM I&D	$3,500.00	$2,500.00	$2,000.00	$2,000.00	$10,000.00
MAREEBA - ASSET COND INSPECTIONS AM I&D	$2,667.10	$2,702.10	$245.10	$2,000.00	$7,614.30
ST GEORGE -ASSET COND INSPECTIONS AM I&D	$3,518.00	$1,927.60	$919.00	$2,000.00	$8,364.60
Grand Total	$35,107.70	$28,210.50	$16,839.60	$12,683.27	$92,841.07

APPENDIX E

HARDWARE COMPARISON

Field Mobility Hardware Evaluation

Product	iPad (Retina)	iPad Mini	iPhone 5	Samsung Galaxy Tab 3
Supplier/Manufacturer	Apple	Apple	Apple	Samsung
Description of Hardware	Tablet computer.	Tablet computer.	Mobile phone.	Tablet computer.
Website	http://www.apple.com/au/ipad/overview/	http://www.apple.com/au/ipad-mini/overview/	http://www.apple.com/au/iphone/	
Year of Release				
Handheld Device	Tablet	Tablet	Mobile Phone	Tablet
Rugged Enclosure Required	Yes	Yes	Yes	Yes
SCORE	**0**	**0**	**0**	**0**
Enclosure/Cost ($)	$130	$100	$80	$50
SCORE	**1**	**2**	**2**	**2**
Operating System	iOS	iOS	iOS	Android Jelly Bean 4.1
Water Resistant	Yes	Yes	Yes	No
SCORE	**1**	**1**	**1**	**-1**
Multipurpose	Yes	Yes	Yes	Yes
SCORE	**2**	**2**	**2**	**2**
Shock Resistant	Yes	Yes	Yes	Yes
SCORE	**2**	**2**	**2**	**2**
Toughened Glass	No	No	No	No
SCORE	**0**	**0**	**0**	**0**
Touchsreen/Stylus	Both	Both	Both	Both
SCORE	**2**	**2**	**2**	**2**
Screen Size (inch)	9.7	7.9	4	7
SCORE	**1**	**1**	**0**	**1**
Visibility in Sunlight	No	No	No	No
SCORE	**-1**	**-1**	**-1**	**-1**
Ingress Protection Rating	68	68	68	0
SCORE	**1**	**1**	**1**	**-1**
GPS	Yes	Yes	Yes	Yes
SCORE	**1**	**1**	**1**	**1**
Camera (Mega Pixel)	5	5	8	3
SCORE	**1**	**1**	**2**	**0**
Battery Life (hours)	10	10	8	8
SCORE	**2**	**2**	**1**	**1**
Network	Wi-Fi/Cellular	Wi-Fi/Cellular	Wi-Fi/Cellular	Wi-Fi
SCORE	**2**	**2**	**2**	**-1**
Storage Size (GB)	16/32/64/128	16/32/64	16/32/64	16
SCORE	**1**	**1**	**1**	**1**
Unit Price (AUD $)	679/789/899/1009	509/619/729	799/899/999	230
SCORE	**1**	**1**	**1**	**2**
TOTAL SCORE	**17**	**18**	**17**	**10**

Field Mobility Hardware

Product	Samsung Galaxy S4 Active	BlackBerry Z10	Windows Surface	HTC One	Yuma
Supplier/Manufacturer	Samsung	BlackBerry	Windows	HTC	Trimble
Description of Hardware	Mobile phone.	Mobile phone.	Tablet computer.	Mobile phone.	Rugged tablet computer.
Website	http://www.samsung.com/uk/consumer/mobile-devices/smartphones/android/GT-I9295ZAABTU-spec	http://us.blackberry.com/smartphones/blackberry-z10.html	http://www.microsoft.com/surface/en-ca	http://www.gsmarena.com/htc_one-5313.php	http://www.trimble.com/Outdoor-Rugged-Computers/yuma.aspx?dtID=features
Year of Release					
Handheld Device	Mobile Phone	Mobile Phone	Tablet	Mobile Phone	Rugged Tablet
Rugged Enclosure Required	Yes	Yes	Yes	Yes	No
SCORE	**0**	**0**	**0**	**0**	**1**
Enclosure/Cost ($)	$80	$80	0	$35	0
SCORE	**2**	**2**	**0**	**2**	**0**
Operating System	Android 4.2.2 (Jelly Bean)	BlackBerry	Windows RT	Android v4.1.2 (Jelly Bean)	Windows 7
Water Resistant	Yes	No	No	No	Yes
SCORE	**1**	**-1**	**-1**	**-1**	**1**
Multipurpose	Yes	Yes	Yes	Yes	Yes
SCORE	**2**	**2**	**2**	**2**	**2**
Shock Resistant	Yes	Yes	No	Yes	Yes
SCORE	**2**	**2**	**-1**	**2**	**2**
Toughened Glass	No	No	No	No	Yes
SCORE	**0**	**0**	**0**	**0**	**1**
Touchsreen/Stylus	Both	Both	Both	Both	Both
SCORE	**2**	**2**	**2**	**2**	**2**
Screen Size (inch)	5	4.2	10.6	4.7	7
SCORE	**0**	**0**	**1**	**0**	**1**
Visibility in Sunlight	No	No	No	No	Yes
SCORE	**-1**	**-1**	**-1**	**-1**	**2**
Ingress Protection Rating	68	0	0	0	67
SCORE	**1**	**-1**	**-1**	**-1**	**1**
GPS	GPS/GLONASS	Internal GPS + GLONASS	No	Internal GPS + GLONASS	Internal GPS SiRFStarIII
SCORE	**1**	**1**	**-1**	**1**	**1**
Camera (Mega Pixel)	8	8	1	UltraPixel (13+)	2
SCORE	**2**	**2**	**0**	**2**	**0**
Battery Life (hours)	8	10	8	18	8
SCORE	**1**	**2**	**1**	**2**	**1**
Network	Wi-Fi/Cellular	Wi-Fi/Cellular	Wi-Fi/Cellular	Cellular	Wi-Fi/Cellular
SCORE	**2**	**2**	**2**	**1**	**2**
Storage Size (GB)	64	16	32/64	32/64	32/80
SCORE	**1**	**1**	**1**	**1**	**1**
Unit Price (AUD $)	600	588	350	600	Pre-purchased
SCORE	**1**	**1**	**2**	**1**	
TOTAL SCORE	**17**	**14**	**6**	**13**	**18**

Field Mobility Hardware

Product	Yuma 2	ET1	MC67	Toughpad FZ-A1	Toughpad JT-B1	Toughpad FZ-G1
Supplier/Manufacturer	Trimble	Motorola	Motorola	Panasonic	Panasonic	Panasonic
Description of Hardware	Rugged tablet computer.	Rugged tablet computer.	Rugged handheld computer.	Rugged tablet computer.	Rugged tablet computer.	Rugged tablet computer.
Website	http://www.trimble.com/Outdoor-Rugged-Computers/Yuma2.aspx?dtID=features	http://www.motorolasolutions.com/XA-EN/Business+Product+and+Services/Tablets/ET1+Enterprise+Tablet#	http://www.motorolasolutions.com/XA-EN/Business+Product+and+Services/Mobile+Computers/Handheld+Computers/MC67	http://www.panasonic.com/business/toughpad/us/best-android-rugged-tablet-overview.asp	http://www.panasonic.com/business/toughpad/us/rugged-b1-android-tablet-overview.asp	http://www.panasonic.com/business/toughpad/us/windows-tablet-fz-g1.asp
Year of Release						
Handheld Device	Rugged Tablet	Rugged Tablet	Rugged Handheld	Rugged Tablet	Rugged Tablet	Rugged Tablet
Rugged Enclosure Required	No	No	No	No	No	No
SCORE	**1**	**1**	**1**	**1**	**1**	**1**
Enclosure/Cost ($)	0	0	0	0	0	0
SCORE	**0**	**0**	**0**	**0**	**0**	**0**
Operating System	Windows 7	Android 2.3.4	icrosoft Embedded Handheld 6.5 P	Android 4.0	Android 4.0	Windows 8 Pro
Water Resistant	Yes	Yes	Yes	Yes	Yes	Yes
SCORE	**1**	**1**	**1**	**1**	**1**	**1**
Multipurpose	Yes	No	No	Yes	Yes	Yes
SCORE	**2**	**-1**	**-1**	**2**	**2**	**2**
Shock Resistant	Yes	Yes	Yes	Yes	Yes	Yes
SCORE	**2**	**2**	**2**	**2**	**2**	**2**
Toughened Glass	Yes	Yes	No	No	No	No
SCORE	**1**	**1**	**0**	**0**	**0**	**0**
Touchsreen/Stylus	Both	Touchscreen	Keypad	Both	Both	Touchscreen
SCORE	**2**	**1**	**0**	**2**	**2**	**1**
Screen Size (inch)	7	7	3.5	10.1	7	10.1
SCORE	**1**	**1**	**0**	**1**	**1**	**1**
Visibility in Sunlight	Yes	No	Yes	Yes	Yes	Yes
SCORE	**2**	**-1**	**2**	**2**	**2**	**2**
Ingress Protection Rating	65	54	65	65	65	65
SCORE	**1**	**-1**	**1**	**1**	**1**	**1**
GPS	Internal GPS SBAS	Yes	Internal GPS (A-GPS) SUPL 1.0	Dedicated GPS	Dedicated GPS	Option
SCORE	**1**	**1**	**1**	**1**	**1**	**1**
Camera (Mega Pixel)	5	8	8	5	13	3
SCORE	**1**	**2**	**2**	**1**	**2**	**0**
Battery Life (hours)	8	5	8	10	8	8
SCORE	**1**	**0**	**1**	**2**	**1**	**1**
Network	Wi-Fi/Cellular	Wi-Fi/Cellular	Wi-Fi/Cellular	Wi-Fi/Cellular	Wi-Fi/Cellular	Cellular
SCORE	**2**	**2**	**2**	**2**	**2**	**1**
Storage Size (GB)	64/128	32	32	16	16	128/256
SCORE	**1**	**1**	**1**	**1**	**1**	**1**
Unit Price (AUD $)	3500	1400	2000	1600	1300	3500
SCORE	**-1**	**0**	**0**	**0**	**0**	**-1**
TOTAL SCORE	**18**	**10**	**13**	**19**	**19**	**14**

APPENDIX F

SOFTWARE COMPARISON

Field Mobility Software Evaluation

Product	ArcGIS Mobile 10	Collector App V10.1	Collector App V10.2.1	Celstra In-field Inspections
Owner	ESRI	ESRI	ESRI	Celstra Infocom Private Limited/SAP
Description of Solution	A windows based ESRI application that allows users to carry out mapping, spatial query, sketching, GPS integration and GIS editing.	Collector for ArcGIS improves your productivity with intuitive data collection. It's designed specifically for iPhone and Android smartphones.	Collector for ArcGIS improves your productivity with intuitive data collection. It's designed specifically for iPhone and Android smartphones.	
Website	http://www.esri.com/software/arcgis/arcgismobile	http://www.esri.com/software/arcgis/smartphones/collector-app	http://blogs.esri.com/esri/arcgis/2013/10/10/collector-v10-2-is-coming-soon/	https://store.sap.com/sap/cpa/ui/resources/store/html/SolutionDetails.html?pid=0000009230&pcnty=US
Operating System	Windows			Android v2.3 +, iOS
Handheld Device	Yes	Yes	Yes	Yes
SCORE	**1**	**1**	**1**	**1**
GPS	Yes	Yes	Yes	Yes
SCORE	**1**	**1**	**1**	**1**
Camera	Yes	Yes	Yes	Yes
SCORE	**1**	**1**	**1**	**1**
SAP Integration	No	No	No	Yes
SCORE	**0**	**0**	**0**	**1**
ESRI Integration	Yes	Yes	Yes	No
SCORE	**1**	**1**	**1**	**0**
SAP & ESRI Integration	No	No	No	No
SCORE	**0**	**0**	**0**	**0**
Multiple Operating Systems	No	Yes	Yes	No
SCORE	**-1**	**2**	**2**	**-1**
Offline Data Recording	Yes	No	Yes	Yes
SCORE	**2**	**-1**	**2**	**2**
Navigation	No	Yes	Yes	No
SCORE	**-1**	**2**	**2**	**-1**
TOTAL SCORE	**4**	**7**	**10**	**4**

Field Mobility Software Evaluati

Product	SAP Rounds Manager	Trimble Field Inspector	Sap Work Manager Mobile	Data Collection Application
Owner	Syclo	Trimble		Click Software
Description of Solution	A mobile application that allows users to enter measurement readings, generate notifications, automatically calculate readings, trend readings etc with SAP integration.	Trimble Field Inspector software for handhelds operates on specific Trimble handheld computers and allows field workers to use simple yet powerful forms to capture data in the field and transfer it automatically back to the office.	Empower your workforce with everything they need to efficiently install, inspect, maintain, and repair assets in the field. The SAP Work Manager mobile app also mitigates the risk of injury by helping workers complete safety checks and follow safe work practices	The Data Collection App provides easily configurable fields and forms which allow companies to efficiently gather data. Integration to back office data sources for analysis and processing returns value through the agility to respond to the field, and/or the market in hours and days instead of weeks and months.
Website	https://store.sap.com/sap/cpa/ui/resources/store/html/SolutionDetails.html?pid=0000009251&catID=MOB&pcntry=AU&sap-language=EN&_cp_id=id-1375237986138-0	http://www.trimble.com/fieldinspector.shtml	http://www54.sap.com/pc/tech/mobile/software/lob-apps/work-manager-app/index.html	http://www.clicksoftware.com/mobility-solutions-apps-data-collection.htm
Operating System	Android, iOS and Windows	Windows		
Handheld Device	Yes	Yes	Yes	Yes
SCORE	**1**	**1**	**1**	**1**
GPS	No	Yes	No	Yes
SCORE	**-1**	**1**	**-1**	**1**
Camera	No	Yes	Yes	Yes
SCORE	**-1**	**1**	**1**	**1**
SAP Integration	Yes	No	Yes	No
SCORE	**1**	**0**	**0**	**0**
ESRI Integration	No	Yes	Yes	No
SCORE	**0**	**1**	**0**	**0**
SAP & ESRI Integration	No	No	Yes	No
SCORE	**0**	**0**	**3**	**0**
Multiple Operating Systems	No	No	No	No
SCORE	**-1**	**-1**	**-1**	**-1**
Offline Data Recording	No	No	No	Yes
SCORE	**-1**	**-1**	**-1**	**2**
Navigation	No	No	No	No
SCORE	**-1**	**-1**	**-1**	**-1**
TOTAL SCORE	**-3**	**1**	**1**	**3**

APPENDIX G

SUB TYPES

Condition Assessment Types - Sub Types

VALUE	CODE	DESC
ACTU	1	Actuators
AIRV	2	Air Valve Assemblies
AVNT	3	Air Vent Assemblies
BENF	4	Bench Flumes - Concrete
BGTE	5	Baulks & Bulkhead Gates
BLDG	6	Buildings
BUOY	7	Marker Buoys
CLCAY	8	Channel Lining - Clay
CLCONC	9	Channel Lining - Concrete
CLPLAS	10	Channel Lining - Plastic
CLUNL	11	Channel Earthworks
CPG	12	Cathodic Protection
DRAIN	13	Drain Earthworks
EWKS	14	Earthworks
FCNG	15	Fencing, Gates & Grids
FMTR	16	Meter Outlet - Bulk
GATES	17	Fixed Wheel Gates, Slide Gates & Radial Gates
HEADER	18	Header
HOUSE	19	Houses
HV_L&SP	20	Lightning and Surge Protection
INST	21	Instruments
MO	22	Meter Outlet - Customer
MWK	23	Miscellaneous Metalwork
PIPEA	24	Pipes - Ancillary
PIPEC	25	Pipelines - Concrete
PIPEF	26	Pipelines - Ferrous
PIPEP	27	Pipelines - Plastic
PUMP	28	Pumps
PWKS	29	Protected Works
RGTE	30	Regulating Gates
ROAD	31	Access Roads
SCDA	32	Controls and SCADA
SCOUR	33	Scour Valve Assemblies
SCRN	34	Trashracks & Screens
SOLAR	35	Solar
STRUC	36	Structures - Concrete
STRUC COMB	37	Combination Structure
STRUC_CD	38	Structures - Channel and Drain Structures
STRUCW	39	Structures - Timber
STRUS	40	Structures - Steel
SUTK	41	Tanks - Steel
SUTK_CON	42	Tanks - Concrete
SWB	43	Switchboards
TKPL	44	Tanks - Poly
VLV	45	Valves
XDRN	46	Cross Drains

APPENDIX H

RATINGS

C1: STRUC CAP TYPE (subtype)

Structures - Concrete:

Includes all concrete structures not in-line (in the waterway) of channels and drains i.e. Pump wells, miscellaneous pits (swabbing, valve, instrumentation), concrete tanks.

CATEGORIES RATINGS AND DESCRIPTIONS

Aspect	Assessment Parameter	Rating 1	Rating 2	Rating 3	Rating 4	Rating 5	Rating 6
Structural Integrity	Cracking / Spalling / Reinforcing Steel Corrosion	Structure sound - no cracking evident	Some minor cracking evident that has little impact on the structures strength	Cracking becoming more evident however still little impact on structural integrity, minor or no corrosion of reinforcement	Cracking/spalling evident that has impacted on the assets structural integrity, reo exposed and corroding.	Significant cracking evident that presents a high probability of the structures collapse, spalling and heavy corrosion of reo	Structure has effectively failed.
Structural Movement	Stability / Functional Impacts	No movement evident	Some minor movement evident that has little impact on the structures strength or function	Asset has moved significantly however structural integrity and function are retained	Movement has impacted on the assets structural integrity or function	Movement has severe impact on structural integrity or function with a high likelihood of failure	Structure has effectively failed and requires renewal to restore service delivery.
Foundations	Undermining/ Stability / Erosion	No erosion/undermining evident	Some minor erosion/undermining that has little impact on structure stability	Asset has significant erosion to foundations, little undermining and structure stability is not immediately threatened	Asset has significant erosion and some undermining to foundations, structural stability is threatened with high probability of partial failure	Asset has severe erosion and/or undermining to foundations with high probability of full failure	Structure has effectively failed and requires renewal to restore service delivery.
Function	Performance Deterioration / Increased Operational Costs	Asset able to perform its intended function	Some minor elements of the assets function are not able to be provided	Minor operational difficulties or costs being presented by the loss of function	Significant operational difficulties or costs presented by the loss of function.	Asset provides very little of its intended function and requires enhancement to correct.	Asset no longer able to perform its intended function
Metalwork/ Coating	Cracking / Flaking / Corrosion	Coating as new, no defects.	Coating showing signs of aging, no visible defects.	Coating loss / deterioration exposing steel. Steel surface corroding / rusting.	Coating loss / deterioration exposing steel. Steel corroding / rusting with surface delamination / flaking.	Steel heavily corroded / rusting with large areas of surface delamination / flaking.	No coating or coating ineffective. Steel corroded / rusted through.
Structural Integrity	Cracking / Spalling / Reinforcing Steel Corrosion	Structure sound - no cracking evident	Some minor cracking evident that has little impact on the structures strength	Cracking becoming more evident however still little impact on structural integrity, minor or no corrosion of reinforcement	Cracking/spalling evident that has impacted on the assets structural integrity, reo exposed and corroding.	Significant cracking evident that presents a high probability of the structures collapse, spalling and heavy corrosion of reo	Structure has effectively failed.

Notes: 1. Status - Failure is a life limiting or failure mode criteria, Other is a deterioration indication criteria that requires another mechanism to cause failure

APPENDIX I

MAP OF TRIAL AREA

Map Produced By:
Infrastructure Development
Tel: (07) 3120 0000

Document: T:\Water Services\Drafting\Project_Files\ENG4111 - Research Project\Drawings\ArcMap\Basemap - BHWSS.mxd
Printed: Thursday, 17/10/2013 03:25:09 PM

N
W E
S

LEGEND

- Roads

SUNWATER INFRASTRUCTURE

- Concrete Lined Channel
- Plastic Lined Channel
- Earth Channels
- Pipelines
- Earth Drains
- Bank/Storage

MAP INFORMATION

Projected Coordinate System: Mapping Grid of Australia (MGA94), Zone 55.

SCALES (A3 SIZE)

0 1,000 2,000 3,000 4,000 5,000 m 1:100,000

SunWater

BURDEKIN HAUGHTON WATER SUPPLY SCHEME

BARRATTA SYSTEM
MOBILE DATA CAPTURE
TRIAL DATA LOCATION
APPENDIX I

APPENDIX J

SUNWATER SAFE WORK METHOD STATEMENT

SunWater ABN 17 020 276 523

Safe Work Method Statement - Template

Form No: WHS10 F1
Revision: 11
Revision Date: NOV 2011

Job Name: Condition Assessment *(Job Location and Description):*	**Work Order Number:** N/A
Name of the person in control on site: Fiona Nielson	**Work Commencement Date: To Be Determined**

A. Is there adequate evidence that SunWater staff and contractors are trained and competent to carry out this task safely?	☐ Yes ☐ No (if no stop work)
B. If contractors are engaged and have produced a Safe Work Method Statement (JSAE), is it suitable and authorised by SunWater?	☐ Yes ☐ No (if no stop work)

NOTE:
- **a) If Contractors are involved in any of the planned work within this safe work method statement it must be thoroughly discussed and communicated with all parties.**
- **b) Following the consultation all parties must sign (on the last page) to indicate that adequate consultation has been undertaken and all risk controls will be followed.**

USE THIS CHECKLIST TO HELP IDENTIFY HAZARDS. Then consider these in the below Safe Work Method Statement.

POTENTIAL HAZARDS IN THIS JOB? *Tick and include in the safe work method statement*	☐ Air Contaminants	☐ Mobile Plant Risks	☐ Chemical spills	☐ Noise	☐ Tools (Poor, Home made)
	☐ Stored Energy	☐ Eye Irritation/Injury	☐ Decanting chemicals	☐ Overhead Wires	☐ Traffic Management Plan
	☐ Asbestos	☐ Falling Hazards	☐ Driving Fatigue	☐ PPE Required	☐ Underground Service Check (DBYD)
	☐ Hazardous Chemicals	☐ Fire Risks	☐ Cranes and lifting	☐ Remote Area Work	☐ Wildlife Risks
	☐ Confined Spaces	☐ Bites/Stings	☐ Hazardous Manual Handling	☐ Restricted Access	☐ Vehicles / Pedestrians
	☐ Trenches	☐ Fatigue Management	☐ Sun Exposure	☐ Slips, Trips, Falls	☐ Water/Drowning
	☐ Electrical Hazards	☐ Explosion	☐ Moving Parts (machinery)	☐ Permits Required	☐ Weather Conditions
	☐ Site Security	☐ Boat Safety			☐ Working Heights

USE THIS CHECKLIST TO HELP IDENTIFY REQUIRED PERSONAL PROTECTION EQUIPMENT (PPE). Then consider these in the Safe Work Method Statement below.

POSSIBLE PPE REQUIRED FOR THE JOB? *Tick and include in the safe work method statement*	☐ ~~Barricades & warning signs~~	☐ ~~Mechanical lifting aids~~	☐ First aid kit	☐ ~~Hard hat and chin strap~~	☐ ~~Rubber boots~~
	☐ Broad brim hat	☐ ~~Overalls~~	☐ Fire extinguisher	☐ Hi visibility vest	☐ Torch and batteries
	☐ ~~Carry bag for tools~~	☐ ~~Overalls for chemical use~~	☐ Fire blanket	☐ ~~Lighting system~~	☐ Drinking water
	☐ Communications equipment	☐ ~~life jacket or life ring~~	☐ ~~Knee pads~~	☐ Safety footwear	☐ Wasp/ant spray
	☐ ~~Dusk mask /vapour mask~~	☐ ~~Personal isolation locks~~	☐ ~~Gas detector~~	☐ ~~Safety harness and lines~~	☐ ~~Face shield~~
	☐ ~~Ear muffs/plugs~~	☐ ~~Rescue kit (for height work)~~	☐ ~~Gloves - chemical~~	☐ Burns kit	☐ ~~Portable toilet~~
	☐ Eye protection (clear or tinted)	☐ ~~Breathing Apparatus (kit)~~	☐ ~~Gloves - cotton/ Leather~~	☐ Sunscreen	☐ ~~Shade protection~~

STEPS IN COMPLETING THE SAFE WORK METHOD STATEMENT

a) DOCUMENT EACH JOB STEP AND THEN POTENTIAL HAZARDS ASSOCIATED WITH EACH JOB STEP. You must then assess the risks and document the Initial Risk Rating before any risk controls are considered.
b) Document the controls or methods you plan to use to lower the risk.
c) Assign who will be responsible for making sure the controls are undertaken.
d) Conduct the residual risk rating.
e) **Do not proceed with the work if the risk rating, after the controls are in place, remains at HIGH or EXTREME**.
f) Remember this Safe Work Method Statement may need to be amended or added to, if a new or unforseen risk arises. This means STOP work and repeat the above steps

Likelihood	Consequence					
	Minor (3)	Moderate (8)	Signifi-cant (18)	Major (40)	Critical (100)	Catast-rophic (235)
Almost Certain (235)	M 705	H 1880	E 4230	E 9400	E 23500	E 55225
Likely (100)	M 300	H 800	H 1800	E 4000	E 10000	E 23500
Possible (45)	L 135	M 360	H 810	H 1800	E 4500	E 10575
Unlikely (20)	L 60	L 160	M 360	H 800	H 2000	E 4700
Rare (10)	L 30	L 80	M 180	M 400	H 1000	H 2350
Very Rare (3)	L 9	L 24	L 54	L 120	M 300	M 705
Extremely Rare (1)	L 3	L 8	L 18	L 40	L 100	M 235

Step No	List the job steps in order. i.e. planning, packing ute, setting up site, inductions, steps to do job, reinstating site. (limited example only)	Potential Hazards in each job step without controls in place (WH&S, Environment, Other)	Initial Risk Rating	Risk Control Actions	Responsibility for the Risk Control Action	Residual Risk Rating
1	Preparations in Office	Nil	L	Nil	Nil	L
2	Travelling to/from Site	Fatigue Vehicle Incident Locomotives	M	Ensure adequate rest before and during long driving periods. Alternate drivers when necessary. Drive to the conditions. Be aware of other vehicles on the roads and around structures (i.e. tractors, haulouts, other plant). Be aware of locomotives when condition assessing during the crushing/harvesting periods.	Fiona Nielson	L
3	Carry out condition assessment	Wasp stings, heat stroke, dehydration, sunburn, snake bite, contact with other wildlife, falling in channel.	H	Carry wasp spray, inspect structure from a distance before approaching. Wear appropriate PPE (i.e wide brimmed hat, sunglasses, sunscreen). Carry adequate water supply. Carry snake bite kit in vehicle, PPE (i.e. Boots, long pants). Avoid long grass where possible. Be wary of other wildlife and keep away when present. Ensure you do not ascend structures that do not have adequate guard railing, avoid the sides of open channels.	Fiona Nielson	L
4	Travelling between sites	Weed spread, grass fire	M	Where necessary use wash down bays to avoid the spread of noxious weeds. Be aware off the hazards of using petrol vehicles in areas with dry, long grass. Use diesel vehicles in these areas where possible.	Fiona Nielson	L
5						

6						
7						
8						

List any additional hazards identified during the job. Follow the process to achieve a low to medium risk rating.

Reviewed and endorsed by Site Supervisor or person in control:

Name: Fiona Nielson **Signature:** **Date:**

SIGN OFF FOR ALL PERSONS INVOLVED IN ANY OF THE ABOVE TASKS (to be done prior to starting the job)

Name of the person who ensured that this Safe Work Method Statement was communicated to all employees and contractors involved in the tasks. **Name: Fiona Nielson**

- ***I have reviewed the contents of this Safe Work Method Statement and agree to follow all directions documented.***
- ***If any further risks are identified, work must STOP until risks are documented and controlled to an acceptable level of low or medium.***

All persons on site undertaking work (including contractors)			
Name	**Organisation**	**Signature**	**Date**
Fiona Nielson	**SunWater**		

APPENDIX K

TIMELINE

Project Timeline

This project is to be completed by the due date of the dissertation as determined by the Engineering and Surveying Faculty at the University of Southern Queensland.

Intermediate milestones before final completion are as follows:

Complete preliminary report – Wednesday 19th May

Load Collector App on to iPad – Early June

Begin creation of base maps for mobile device – Early June

Create feature templates for each different asset type – Mid to End June

Create domains and subtypes for asset data – June to July

Trial mobile device in office to ensure program works – End of July

Complete verification of BHWSS data (comparison btwn SAP and GIS) – Early August

Office trial of data and form inputs – August

Field trial of condition assessments in BHWSS – September

Write up results of trial and submit draft dissertation – September

Complete presentation in Toowoomba – Late September

Submit final dissertation – October