LinksPoint White Paper

Field Inventory of Abandoned Mine Sites in Western Australia

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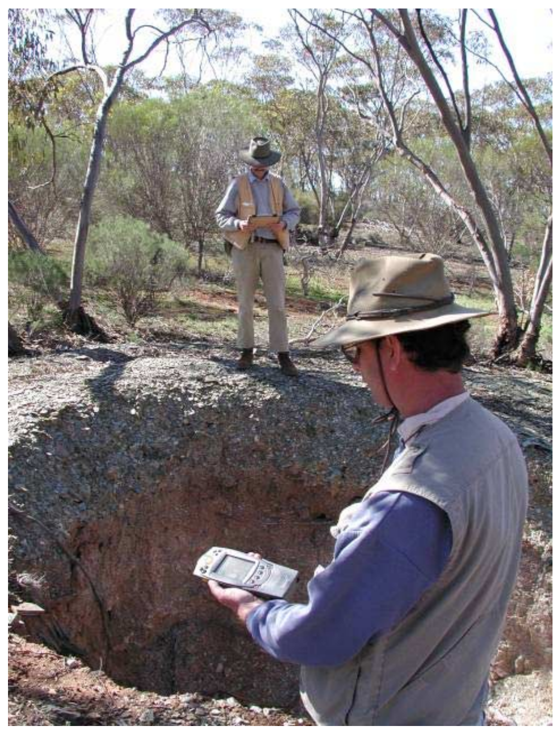
Abstract

The inventory of abandoned mine sites, conducted by the Geological Survey of Western Australia, commenced in 1999 and has focused on mapping sites of historic production, mostly for mines that closed prior to 1990. The project aims to accurately locate and document abandoned mine sites in Western Australia, identify public safety and environmental hazards, and assess their state of preservation. The Western Australian abandoned mine site database (WABMINES) of mine site features has the potential to assist mineral exploration and land use planning in addition to the primary safety and environmental objectives.



Data for the WABMINES database were originally collected using DGPS connected to a Cassiopeia hand-held device. A significant change took place in September 2001 when the team switched from the expensive and heavy Differential GPS (DGPS) equipment to uncorrected GPS following the removal of Selective Availability. The 2002 field season witnessed a significant improvement in productivity following the introduction of the latest hand-held technology.

This paper outlines the program goals, system and field procedures used in this project.

1. Introduction

Mining has occurred in Western Australia (WA) for more than 150 years, resulting in many thousands of workings that were abandoned after exploration or mining (**Figure 1**). Until recently, few of these workings and other associated mine site features were documented and many remain unrecorded.

The Western Australian State government has resourced the Department of Industry and Resources (DoIR) to compile an inventory of the abandoned mine sites for the State. The Geological Survey of Western Australia (GSWA) started the inventory in 1999, and during the first year of the program, a computer database was designed, field equipment purchased and data collection commenced. The project objectives were to accurately locate and document abandoned mine sites, to document factors relevant to the public safety and environmental hazards they pose, to assess their state of preservation, and to quantify the aggregate risk associated with each site. The inventory was intended to provide a sound basis for future planning of the necessary action and rehabilitation at high-risk abandoned mine sites.

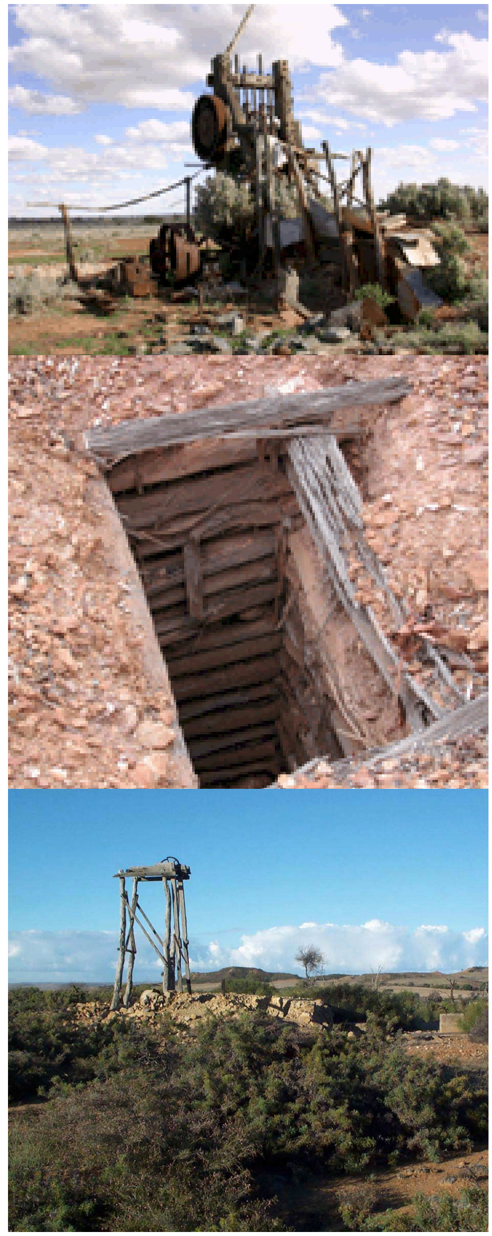


Figure 1 - *Abandoned mine workings in Western Australia*.

The data within this document are sourced from a comprehensive document by Ormsby, W.R., Howard, H.M. and Eaton, N.W., 2003, Inventory of abandoned mine sites: progress 1999-2002. GSWA, Record 2003/9.

The inventory principally consists of individual mining-related features such as shafts, dumps and buildings that are commonly found at sites of historic mine production. Most of these sites have been non-operational since 1990 and are therefore considered to be abandoned. Mines that have closed since 1990 are already well located and have environmental matters addressed within either Notices of Intent to commence mining operations (introduced in 1986) or by DoIR's environmental management system (introduced in 1990). The principal clients of the inventory of abandoned mine sites are the mining industry, the Safety, Health and Environment Division of DoIR, local governments, WA Department of Conservation and Land Management, land leaseholders, Heritage Council of Western Australia, and the public.

Data for the WABMINES database were originally collected using a DGPS connected to a Cassiopeia hand-held device. The 2002 field season witnessed a significant improvement in productivity following the introduction of the latest hand-held technology.

With the new equipment there was an immediate increase in productivity. When gathering information about every feature at a Historic Mine Site – shafts, shallow workings, dumps, infrastructure, etc. – the scope and quality of the information being gathered improved significantly. The team also started to look at improvements and additions, and by the end of the field season was building a more detailed database of features that would not have been possible with the older technology.

2. Overview of methodology

DoIR's mines and mineral deposits information database (MINEDEX) contains all pre-1985 Historic Mine (MH) production sites for Western Australia. Work for the inventory of abandoned mine sites project was prioritized mainly on the proximity of MH sites to towns and main roads, reflecting the major safety objective of the project. Other considerations included records of past accidents, and feedback from local governments. High priority sites were defined as being within 10 km of towns with a population in excess of 200, and within 1 km of major roads.

A number of sources of data assisted in the identification of abandoned mines or target areas for fieldwork in any given area. The most widely used tool was aerial photography, but other sources of information included historical maps, geological maps, historic tenement boundaries, data provided by mining companies, and orthophotographs (aerial photographs that have been referenced to a coordinate system, and corrected to eliminate all variations in scale). Work programs were planned in the office with the assistance of these resources before each field trip.

A purpose-made database was developed for the project, and an application was initially designed using Visual CE and MapPad software. Cassiopeia hand-held personal computers (PCs) where selected for data capture using the Differential Global Positioning System (DGPS) for accurate locations. Both the database and application improved with increased experience and improved technology. Major improvements were made in mid-2002 with the acquisition of Symbol PPT2800 hand-held PCs and LinksPoint clip-on GPS. The Symbol is designed to resist water and rough usage, and after a month of field trials was rolled out to the full team at the beginning of August 2002.

The application was simplified and changed to ESRI ArcPad 6 GIS software under Windows 2002. These changes resulted in a several-fold improvement in the range of data collected and in increased data collection rates. The database structure was also simplified and expanded to incorporate additional useful information. The database itself was moved from a Microsoft Access 97 (MS Access)-based system to the Oracle system, and was integrated with GSWA's Western Australian field observation database (WAROX).

The new application built in ArcPad is faster and easier to use than the original application. The team mostly use colour orthophotography on the hand-held, stored as very compact GeoJPEG images at 0.5 m resolution. Tapping simple notes into the comments field of the database was made attractive because of the word recognition capabilities of the hand-held device. The complex daily download and validation process, which could take 40 minutes in the evening for the old devices, was also much simpler and faster – typically 10 to 15 minutes.

Digital photographs of some feature types were collected from the outset. The use of photographs has subsequently expanded to provide more useful information. The photograph database is now fully integrated with WAROX.

Extensive database validation has been undertaken, and protocols have been established for the validation of new data and the extraction of data for clients.

3. MINEDEX

The MINEDEX database was established by DoIR in 1985, and contains records of the locations and estimated mineral resources and ore reserves of mines and mineral deposits in Western Australia.

There are 11,411 Historic Mine sites (MH) in the MINEDEX database (Figure 2), and 4247 of these (37%) are high priority for field data collection. The initial high priority sites for fieldwork were within 1 km of major roads and 10 km of towns. Future additional priorities include aboriginal communities and tourist/heritage trails, potentially leading to a comprehensive cover of the entire state. To the end of 2003 a total of 4102 MH sites had been completed (75% of high priority sites), with 107 797 mine site features mapped in the field, backed up with 28 940 digital photographs.

The MINEDEX MH sites are the starting point for the prioritization and planning of abandoned mine site field inspections, and are useful for measuring overall progress. Fieldwork has shown that each site may represent anything from a single shaft through to tens of individual mine workings and associated mine features. Commonly, the workings are scattered along a semi-continuous line or zone, and it is difficult or impossible to delineate which are related to any specific site in MINEDEX. Furthermore, there are significant workings in areas well away from MINEDEX sites, either due to the limitations of point data as MH site locations, inaccuracies in the location data, or the absence of specific production records for those sites.

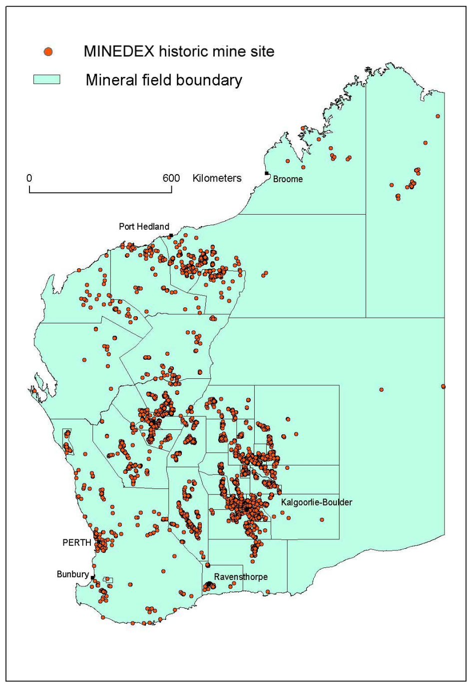


Figure 2 - *Locations of MINEDEX MH sites and mineral fields in Western Australia.*

The digital MH site data are viewed using ArcView GIS (Geographic Information System) software on laptop computers in the office and in the field camp. They can also be loaded onto the hand-held computers carried in the field and used as a navigational aid to assist in locating areas of abandoned mine-related features.

4. Spatial information sources

A combination of spatial information was used for planning, navigation, and targeting purposes in the office and in the field. Aerial photography was the main tool in combination with the MINEDEX MH sites throughout much of the project, and historic geological maps and spatial data provided by mining companies augmented this approach. TENGRAPH plots of topography, MH sites, current mines, and mineral tenements were used routinely in the first three years. In the field, MH site and road data were loaded into the Cassiopeia hand-held PC where appropriate. In year four, orthophotographs, digital historic tenement data and digital geological maps were added as useful tools. The advent of the Symbol PC with LinksPoint GPS made in-field use of orthophotographs and other images possible. Furthermore, flexibility with display point symbols and colours facilitated the use of multiple targeting data in the field. For example, the MH sites could be shown in a different colour to targets selected from orthophotographs, and both could be different to the sites acquired on the previous day.

5. Details of field data acquisition

Data were collected during the first three years of the project using a Cassiopeia PA-2400W hand-held PC linked to a DGPS with the Microsoft Windows CE operating system software. During most of that time, an Omnistar Geomatic Locator DGPS was used, which provided a real-time location with a positional accuracy of within 3 m. The DGPS was connected by cable to the Cassiopeia PC and was carried in a backpack (Figure 3). After the removal of selective availability of the positioning system by the U.S. Government, the standalone positional accuracy of the GPS improved to within 5 m. Consequently, after considerable field-testing, the DGPS was found to be unnecessary, and the more compact Garmin II or Garmin 12 hand-held GPS units, were connected by cable to the Cassiopeia PC from 17 September 2001.

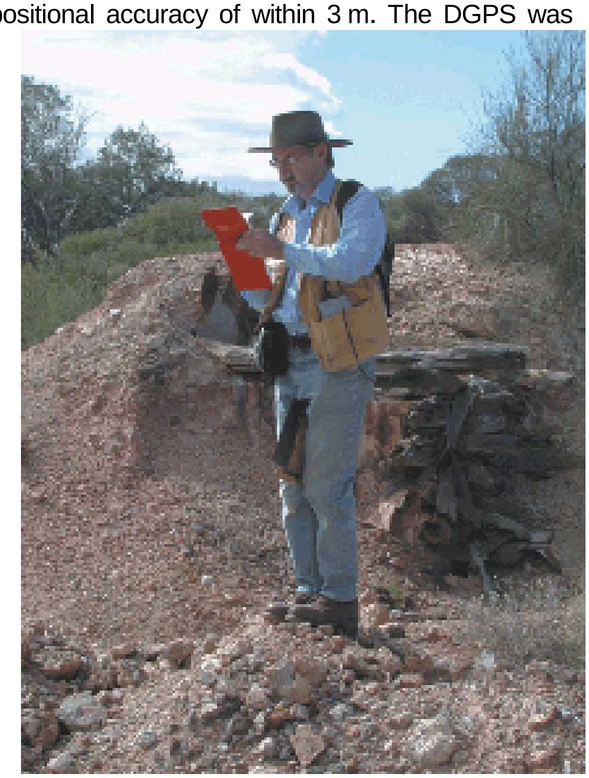


***Figure 3 -** Geologist using a Cassiopeia hand-held personal computer in left pocket connected by cable to the Omnistar Differential Global Positioning System (DGPS) unit in the backpack.*

From 1 August 2002, the data collection system was upgraded to a Symbol PPT 2800 series pocket PC with a clip-on LinksPoint GPS (Figure 4). The positional accuracy remained the same as with the Garmin hand-held GPS, but there were no longer any connecting cables.

The initial database was created as a table in MS Access and copied to the Cassiopeia PC, and the database application forms were designed using Visual CE. The GIS software for the Cassiopeia PC was MapPad, which linked the GPS with the Visual CE application forms. All data were output into a single table in the Cassiopeia PC.

The Symbol PC uses the Microsoft Pocket PC Software 2002 operating system, whereas the application and GIS for the Symbol PC used ArcPad software (Figure 5). The ArcPad application was designed using ArcPad Studio software. Data were output as a dbf file and four ArcView shapefiles.

Field procedures were similar for both the Cassiopeia and Symbol PC based systems. Because the GPS was located in a backpack for the Cassiopeia PC system, the user stood as close as safely possible to the feature, and waited for the GPS coordinates to stabilize. For essentially point data such as shafts, the user stood to the side of the feature. Linear surface features such as costeans were usually recorded from either end, with the trend recorded as a strike, or in comments. Centroids were normally used for smaller linear features or small area-based features such as footings and small dumps. Larger features such as waste dumps and tailings dams were normally recorded from one corner or edge, and the location was described in the comments. The coordinates of other corners were also frequently recorded in the comments. Wherever possible, the location of the feature was also marked on an aerial photograph and labeled with the field site number (which recommenced at 0001 each day).

Figure 4 – *Symbol hand-held PC with clip-on LinksPoint GPS and ESRI ArcPad application.*

5.1 WABMINES application

The application form was displayed once the point was acquired using MapPad, and the user then recorded the various attributes of the feature. With the Cassiopeia PC there was a significant time delay between acquiring the point and the display of the application form. This time delay increased as the number of records increased, and ultimately became a limiting factor to the number of sites that could be recorded in a day. All dimensions were estimated, or measured off aerial photographs for larger features, and the appropriate attributes recorded by stylus on the touch-screen keypad. Orientation measurements were made with a compass where required. Comments were hand written into a field notebook and were periodically transcribed into

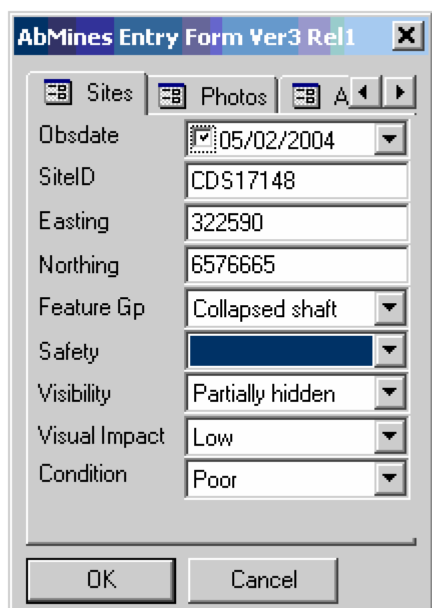


Figure 5 - *Sites page from the ESRI ArcPad application.*

the laptop MS Access database either by hand or with the assistance of voice recognition software.

A problem with the Cassiopeia PC application arose from the retention (or carry over) of successive records on the underground, opencut, infrastructure, and dump pages. To avoid this problem, a 'blank' record was made following every entry of data on these pages. If this procedure was overlooked, false duplicate records were created in the database. Only careful data validation could then correct this problem.

5.2. Digital photographs

Digital photographs were taken initially with a Kodak DC240 zoom digital camera (1.31 Megapixels). During 2001, two Kodak DC3400 zoom digital cameras (2.1 Megapixels) were also used. Until the 2002 field season, one photograph was normally taken for all features more than 2 m deep, and most of these photographs were of shaft collars. In 2002, a new standard of two photographs per shaft was adopted. One photograph was taken a moderate distance away from the feature to highlight its visibility, and the other was a close up of the shaft collar as previously recorded. No limits were placed on the number of photographs, and they were taken to illustrate any aspect of any feature. The unique sequential photograph number was entered for each camera in the application and stored in the database.

5.3. Symbol PC field procedure

The Symbol PC with LinksPoint GPS was held at arms length facing the feature to be located until the GPS reading stabilized. As a guide, a Position Dilution of Precision (PDOP) value of less than five normally indicated a good location fix. The positioning of the GPS was similar to that for the Cassiopeia PC, except that the operator could safely hold the GPS closer to the feature. In contrast to the Cassiopeia PC, the application form was displayed almost immediately after the point was acquired, irrespective of how many records were stored. It was necessary to enter a new site identification number for each feature recorded. This consisted of the user's initials (which were automatically set by the application) followed by a sequential number that was entered on the touch-screen keypad using a stylus. To assist with this the previous site ID number was displayed as soon as the application form opened. The attributes were recorded with a stylus on the touch-screen keypad. The word recognition software enabled comments to be added relatively quickly, so this was done in the field rather than transcribed later. To eliminate record duplication, no data were carried over or retained from one site record to the next in the Symbol PC application.

The Symbol PC enabled more flexibility in the display of data points using the colour screen. Targeting points could, for example, be displayed in a different colour. The display could be set at a fixed scale, and zoomed in or out with the use of toggle switches. Nevertheless, the greater power demands of the colour screen did require changing the small lithium ion batteries up to three times a day (compared with several times a week for dry cell alkaline batteries in the Cassiopeia PC), and there were time delays involved with re-establishing the GPS position. Power management thus became important, and the vehicle 12-volt charger was used wherever possible to top up the battery charge. Connection to the vehicle-mounted aerial was found to quickly re-establish the GPS position after a battery change.

Each team member operated autonomously, but normally in the same general region as the others for safety purposes. In addition, an EPIRB emergency satellite locator beacon was always carried, and, in the fourth year, a Globalstar dual mode GSM/satellite phone was carried to supplement normal GSWA safety precautions.

6. Data management

Data were downloaded daily from both the Cassiopeia and the Symbol PC based systems to a field-based laptop computer. The Cassiopeia PC data downloading was a comparatively slow process that involved using the Visual CE software to synchronize the table in the Cassiopeia PC with a blank MS Access table on the laptop computer. The table was then edited to remove blank records, validated, and appended to the master MS Access table on the laptop computer. A copy of the master table was then exported as a dbf file, and loaded into ArcView as a new table. The table was loaded into ArcView as an event theme so that the data could be viewed. In some cases, a shapefile was created in ArcView to mark the extent of recorded data to avoid duplication of field sites. This file was then copied back into the Cassiopeia PC using ActiveSync and MS Explorer for future reference. Visual CE was used to synchronize a blank MS Access table in the laptop computer with the Cassiopeia PC in readiness for data collection the next day.

The Symbol PC daily data download was much faster. The dbf file and shapefiles were copied to the laptop computer using ActiveSync and MS Explorer. The shapefiles could be loaded directly into ArcView and the dbf file edited using the same program. Daily shapefiles could be renamed and then copied back into the Symbol PC using ActiveSync and MS Explorer for future reference. Alternatively, a copy of the dbf file was imported into MS Access and then either retained as a daily file or appended to an individual master file. Any editing of the data in MS Access would require exporting as a dbf file then loading it as a new table in ArcView, before viewing the data as an event theme, as for the Cassiopeia PC procedure. ActiveSync and MS Explorer were used to copy a blank application table back into the Symbol PC.

Any office-based data entry was either through the Symbol PC application, directly into an MS Access table, or preferably into a purpose-made form called WABMINES_FIELD in the forms part of the wabmines.mdb (i.e. the MS Access database.

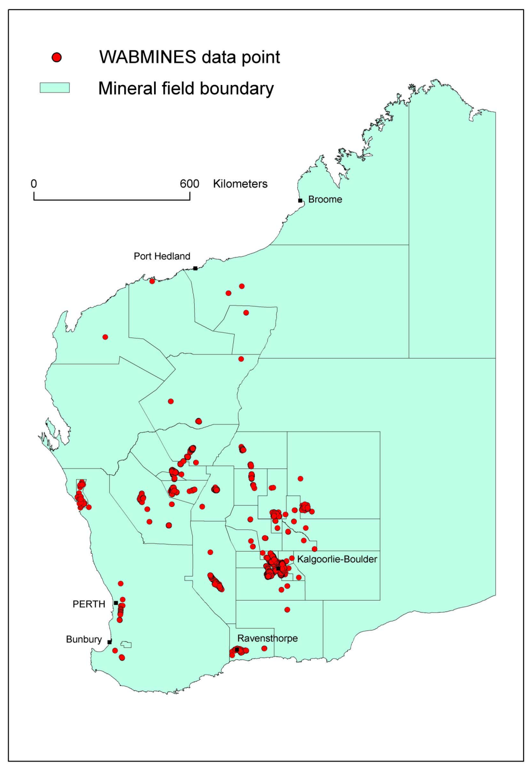


Figure 6 - *Locations of the 107 797 sites in the WABMINES database as at 31st December 2003*

6.1. Data backup

Field data backups were carried out daily, mainly onto a Superdisc high-capacity floppy disk. A complete master copy of the MS Access database was maintained on one central laptop computer throughout the use of the Cassiopeia PC system, and a copy of the database was stored on the Perth office network whenever possible. Each user became responsible for their own copy of their current field data when the Symbol PC system was introduced. This allowed more flexibility in the use of several field laptop computers, and geographically separated teams. Each user submitted a single validated copy of an MS Access database table to the database administrator upon return to the Perth office.

Digital photographs were backed up daily, onto either a laptop computer or a compact disk. In the fourth year, digital photographs were mostly rotated in the field to a vertical format before backup.

7. Number of features collected

As of 31st December 2003, 107 797 features had been collected and included in the project inventory (Figure 6). After an initial ramping up in year one, the number of records stabilized around 24 000/year in years 2 and 3. In the first half of year 4, the number of new records exceeded 31 000, reflecting in part the productivity gains from hardware and software enhancements. The hardware and software enhancements increased the number of features recorded without compromising quality.

8. Conclusion

The use of innovative technology and approaches has made the WABMINES project a success in meetings its goals of effective and accurate field data collection. The team is now well positioned to continue collecting the remaining high priority sites throughout Western Australia in the next 5 years.

9. Acknowledgements

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Biographies

Colin Strickland – Geologist - Abandoned Mine Sites Project, Geological Survey of Western Australia. Colin has had 33 years experience as a mining and exploration geologist searching for a range of commodities including, magnesite, silica, base metals, uranium, tin-tungsten and gold. As an employee and a consultant, his career has involved the management of exploration projects throughout the Northern Territory, Tasmania, Queensland, Western Australia and West Africa. Colin holds a BSc from Auckland University and postgraduate Diploma of Management from Deakin.

Michael Forbes - Vice President – Products & Marketing. Michael has extensive experience in product development, marketing, sales support, and marketing communication initiatives. He is responsible for LinksPoint's transportation product category including vehicle tracking and navigation. He also has been a lead member of the team involved in geographic modeling of West Nile Virus risks for municipal clients. Prior to joining LinksPoint, he developed numerous product innovations for i3 Mobile, including consumer and enterprise wireless data products. Michael holds a BA in Communications from DePauw University.