Subsidence Standardised Information Management System (SSIMS)

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ABSTRACT

The Subsidence group of the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS) receives, analyses and archives surface monitoring data relating to subsidence movements associated with underground coal mining activities. To date, the data is received attached to emails in non-standard formats. The number of files archived is forever growing, as is the size of the files, generating increasing complexities in data management. Subsidence analysis is largely empirically based due to the number of variables involved and their uncertainty. A deep knowledge of mining history and conditions is required to select appropriate sets of data to undertake analysis. As the data received is presented in formats specific to each operator, analysis requires processing the raw data manually in order to run comparisons between the datasets. This is a lengthy process, further hampered by many sets of data being incomplete. While this information is available for recent extractions when requested, it is often impossible to complete for older datasets. In order to resolve these issues, a standardised data format was developed along with a central database repository for existing and future data. The project is funded by the Australian Coal Association Research Program (ACARP) and Mine Safety Operations and started in March 2011. A database was designed for data storage and a web application developed to manage and load the data. The standardised data stored in the database provides for easy filtering and data queries as well as undertaking complex analysis. The collieries use the web browser front-end to submit the monitoring data in an XML format, which is then parsed and validated by the server application. Meanwhile existing archival data is being reformatted and also loaded into the database in bulk. As of October 2013, over 3,000 surveys have been processed. The system facilitates submissions and storage of surface monitoring data and allows for the data to be consistent, accurate and complete, and improves analysis of subsidence.

KEYWORDS: *Subsidence, surface deformation monitoring, data standardisation, data management.*

1 INTRODUCTION

The Subsidence group of Mine Safety Operations NSW collects monitoring survey data received from active underground collieries. The role of the data is to provide up-to-date land deformation information caused by the extraction of underground coal. The monitoring includes surveys of ground surface and infrastructure such as highways, railways, communication cables, electricity towers, sewer systems, dams and pipelines. Monitoring plans including the extent and frequency of the surveys are proposed by the collieries and approved by Mine Safety Operations. Data is generally submitted to Mine Safety officers as Excel spreadsheets.

The number of MS Excel files received and archived is forever growing. Searching the data is only possible with a good knowledge of the folder structure. Moreover, analysis requires an advanced knowledge of what the folders contain and of mining parameters (e.g. overburden height and mining geometry) in order to select files for relevant analysis. The size of the Excel files itself has grown with many files received now over 10 Mb. Some older files cannot be opened with modern versions of MS Excel.

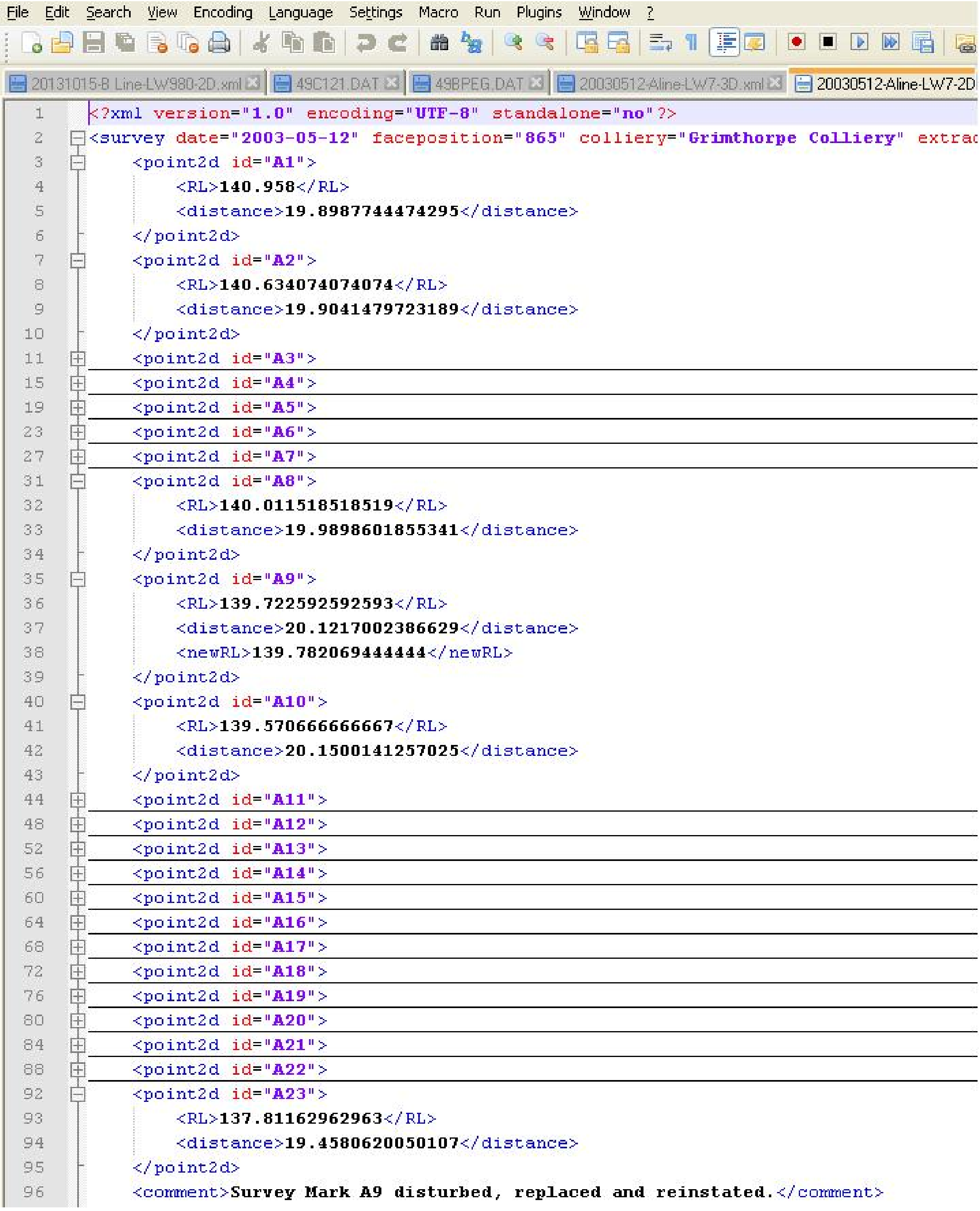
Hence the birth of a project to revisit the data management of the subsidence monitoring results. The project started in March 2011. This paper provides a short introduction of the database solution developed by the Subsidence group at Mine Safety Operations, a branch of the NSW Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS), Division of Resources and Energy.

2 DATABASE DESIGN AND FEATURES

2.1 Standardisation

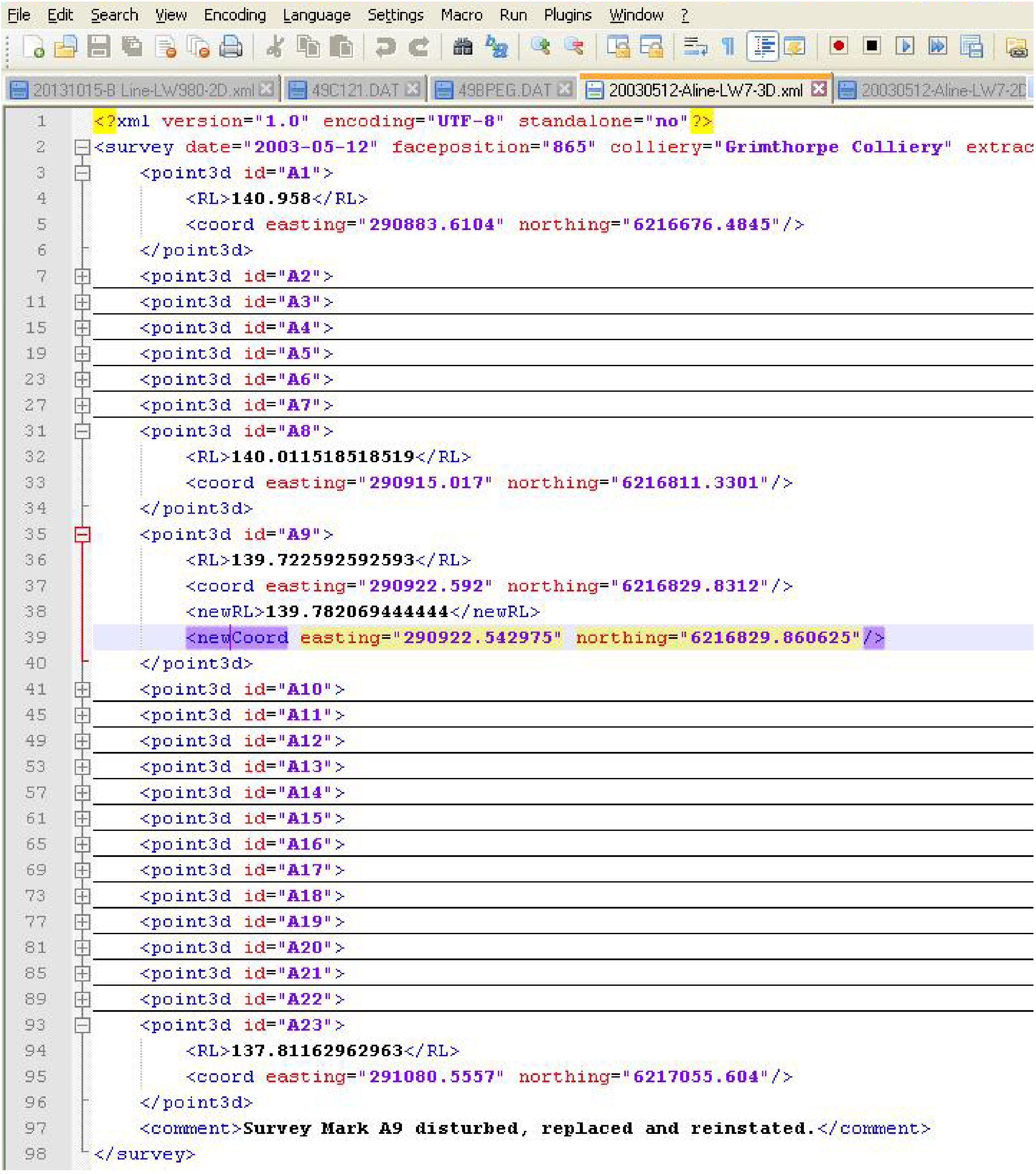
Standardisation refers to the content of the submission and its format. The standardised submissions from the colliery include the date, extraction status on the survey date (i.e. the position of the coal face), the raw data and the extent of the data, with optional comments.

Figures 1 and 2 show examples of standardised Extensible Markup Language (XML) submissions in 2D (RLs and bay distances) and 3D (3D coordinates, MGA or local coordinate system), respectively. It should be noted that survey marks destroyed or disturbed can be reinstalled to ensure continuity of the monitoring (see Figure 2, lines 38-39).




```xml
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<survey date="2003-05-12" faceposition="865" colliery="Grimthorpe Colliery" extrac
    <point2d id="A1">
        <RL>140.958</RL>
        <distance>19.8987744474295</distance>
    </point2d>
    <point2d id="A2">
        <RL>140.634074074074</RL>
        <distance>19.9041479723189</distance>
    </point2d>
    <point2d id="A3">
    <point2d id="A4">
    <point2d id="A5">
    <point2d id="A6">
    <point2d id="A7">
    <point2d id="A8">
        <RL>140.011518518519</RL>
        <distance>19.9898601855341</distance>
    </point2d>
    <point2d id="A9">
        <RL>139.722592592593</RL>
        <distance>20.1217002386629</distance>
        <newRL>139.782069444444</newRL>
    </point2d>
    <point2d id="A10">
        <RL>139.570666666667</RL>
        <distance>20.1500141257025</distance>
    </point2d>
    <point2d id="A11">
    <point2d id="A12">
    <point2d id="A13">
    <point2d id="A14">
    <point2d id="A15">
    <point2d id="A16">
    <point2d id="A17">
    <point2d id="A18">
    <point2d id="A19">
    <point2d id="A20">
    <point2d id="A21">
    <point2d id="A22">
    <point2d id="A23">
        <RL>137.81162962963</RL>
        <distance>19.4580620050107</distance>
    </point2d>
    <comment>Survey Mark A9 disturbed, replaced and reinstated.</comment>
```


Figure 1: XML 2D standard submission.




```
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<survey date="2003-05-12" faceposition="865" colliery="Grimthorpe Colliery" extrac
    <point3d id="A1">
        <RL>140.958</RL>
        <coord easting="290883.6104" northing="6216676.4845"/>
    </point3d>
    <point3d id="A2">
    <point3d id="A3">
    <point3d id="A4">
    <point3d id="A5">
    <point3d id="A6">
    <point3d id="A7">
    <point3d id="A8">
        <RL>140.011518518519</RL>
        <coord easting="290915.017" northing="6216811.3301"/>
    </point3d>
    <point3d id="A9">
        <RL>139.722592592593</RL>
        <coord easting="290922.592" northing="6216829.8312"/>
        <newRL>139.782069444444</newRL>
        <newCoord easting="290922.542975" northing="6216829.860625"/>
    </point3d>
    <point3d id="A10">
    <point3d id="A11">
    <point3d id="A12">
    <point3d id="A13">
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    <point3d id="A21">
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    <point3d id="A23">
        <RL>137.81162962963</RL>
        <coord easting="291080.5557" northing="6217055.604"/>
    </point3d>
    <comment>Survey Mark A9 disturbed, replaced and reinstated.</comment>
</survey>
```
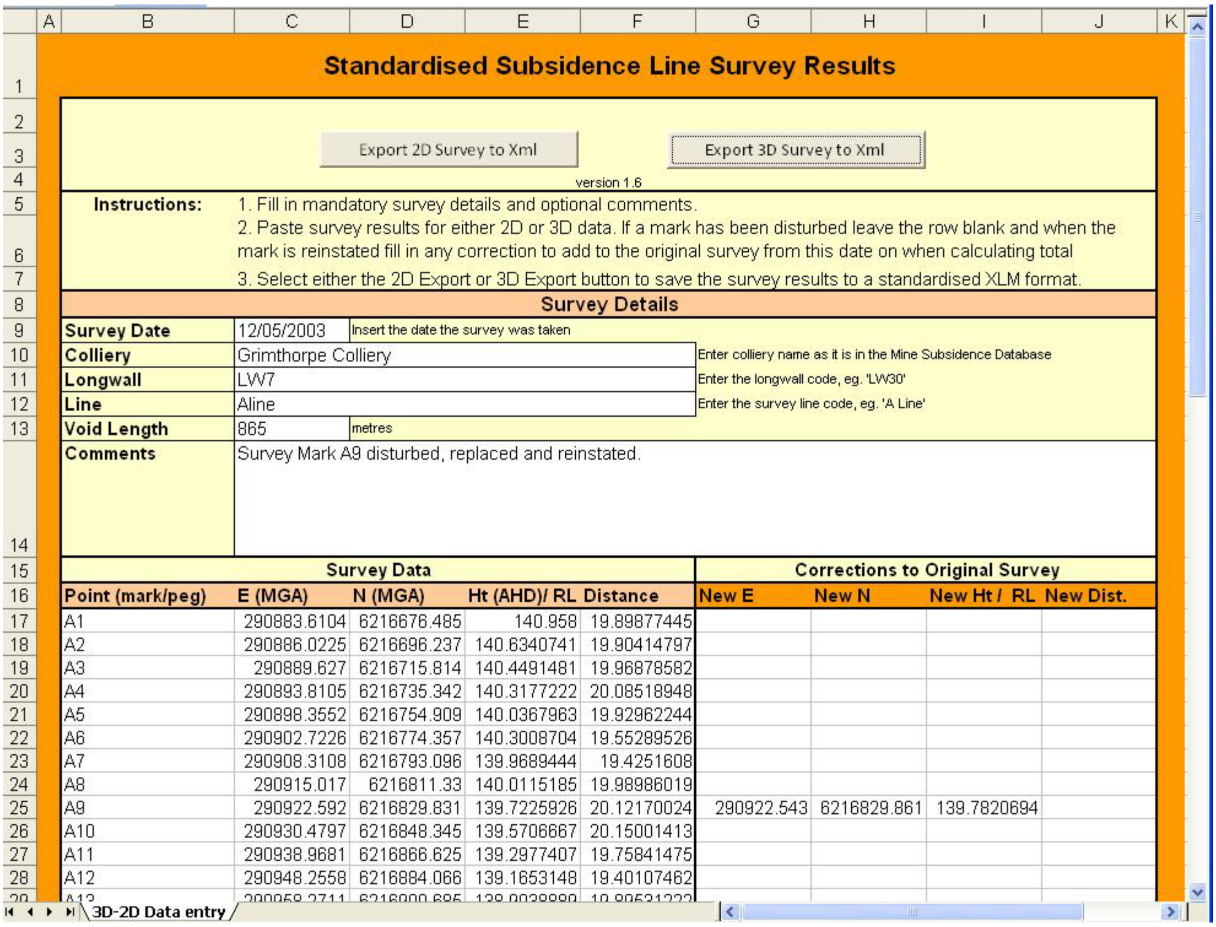


Figure 2: XML 3D standard submission.

The data for the web portal submission is in XML format. The size of the files is up to 800 times smaller than the same data in MS Excel. Upon submission through the web portal, some calculations are undertaken and plotted on the web page at the submission end, to detect possible outliers. Warnings are also displayed for awareness of missing information. Once uploaded, the data is kept in a ‘waiting room’ for compliance inspection and acceptance (or rejection) by a Department officer.

A template (Figure 3) is provided to the collieries to assist in generating the file in standard format. The template allows generating both 2D and 3D submission files. This template was used to generate the files shown in Figures 1 and 2. Some collieries have built the macro into their results, allowing the XML files to be generated directly out of their own MS Excel spreadsheets results.



Survey Data					Corrections to Original Survey			
Point (mark/peg)	E (MGA)	N (MGA)	Ht (AHD)/ RL	Distance	New E	New N	New Ht / RL	New Dist.
A1	290883.6104	6216676.485	140.958	19.89877445				
A2	290886.0225	6216696.237	140.6340741	19.90414797				
A3	290889.627	6216715.814	140.4491481	19.96878582				
A4	290893.8105	6216735.342	140.3177222	20.08518948				
A5	290898.3552	6216754.909	140.0367963	19.92962244				
A6	290902.7226	6216774.357	140.3008704	19.55289526				
A7	290908.3108	6216793.096	139.9689444	19.4251608				
A8	290915.017	6216811.33	140.0115185	19.98986019				
A9	290922.592	6216829.831	139.7225926	20.12170024	290922.543	6216829.861	139.7820694	
A10	290930.4797	6216848.345	139.5706667	20.15001413				
A11	290938.9681	6216866.625	139.2977407	19.75841475				
A12	290948.2558	6216884.066	139.1653148	19.40107462				

Figure 3: Excel template for 2D and 3D data.

2.2 Mine Parameters

The Department enters some data, such as panel names and panel coordinates, seam extracted and the depth of cover under each survey marks. The coordinates of the longwalls determine the geometry of the extraction. The coordinates order also determines information such as the starting end of the longwall and the position of the main gate.

The depth of cover (overburden) under each survey mark is calculated by a script, which executes a Delaunay triangulation of the seam floor data (departmental records received from collieries separately) and calculates the RL of each survey mark at the seam floor level by planar interpolation. The depth of cover is then the difference between the RL of the mark on the topographic surface and its level at the seam. The coordinates of survey marks where MGA information is not available are estimated manually.

2.3 Database and Web Portal

A database was designed to accommodate the mine parameters and to accept and manage the survey submissions. This database was implemented in Microsoft SQL Server 2008 R2 and is hosted by the Department. A web portal was also designed for subsidence surveyors to submit compliance surveys on a regular basis, and to allow the Department to manage and analyse this data. This web application was implemented in ASP.Net MVC 4 and is hosted on

Windows Server 2008 R2.

Due to the standardisation of survey data, implemented in XML, it is also possible for future implementations to allow colliery systems to directly submit the mine subsidence system via a web service. The web portal has been in operation since May 2013, following a 6-month trial with three collieries. All NSW underground collieries are now submitting their survey data via the portal in a standardised format.

Work is underway to add analytical capabilities to the web portal to plot aggregate data, which will assist future mine applications in better predicting land deformation.

3 DATABASE CAPABILITIES

3.1 General

The database project allows the management of a large quantity of survey data. Filtering the data permits searching the database. Filtering replaces the manual selection of files, resulting in a thorough systematic search not based on an individual officer's knowledge of historical mining. Filtering for example can assemble complete tables of data according to the coalfield, a range of depth of cover, in a very short time. This type of work is time consuming if undertaken manually. Moreover, the data exported is in a standard format and includes all of the information necessary for immediate analysis.

3.2 Analysis

Although development of this aspect of the database capabilities has just started, the database is already proving to be a valuable tool for analysis. The data can be filtered to allow the assembly of tables to proceed to complex analysis tasks.

Subsidence prediction is essentially an empirical science as it involves many variables not easily identified and built in the analysis. Predictions are used commonly to prepare new subsidence management plans and new monitoring proposals.

The aim of the project is:
(a) To allow collieries to access their own data in aggregate format.
(b) To allow all the collieries to access pre-analysed statistical data in order to help with subsidence predictions for new extractions. Examples of types of subsidence effects, subsidence monitoring and analysis of results can be found in Kratzsch (1983), Whitaker and Reddish (1989), Holla (1991), Holla and Barclay (2000) and Peng (2006).

4 CONCLUDING REMARKS

Faced with an ever-growing number of larger land deformation monitoring files, the Subsidence group of Mine Safety Operations NSW has opted for a database solution in early 2011. The database and portal now in place are the result of the close collaboration between departmental subsidence data experts and an IT database consulting firm. Two keywords characterise the project: standardisation and data management. This is a long-term project due to the large number of archived data to be imported. A web portal is used by departmental engineers to import the data. The same portal is also used by the collieries to submit new data to the department, in the standard format adopted for the database.

ACKNOWLEDGEMENTS

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