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Digital field data capture in the York area - feedback and recommendations on the digital notebook application

Digital Geoscience Spatial Model

Internal Report IR/05/005



SYSTEM FOR INTEGRATED GEOSPATIAL MAPPING

BRITISH GEOLOGICAL SURVEY

INTERNAL REPORT IR/05/005

Digital field data capture in the York area - feedback and recommendations on the digital notebook application

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Front cover

Section logging using the digital notebook application (near Malton). Photo by C Jordan © NERC.

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1 Introduction

This report provides feedback and recommendations following field trials of the beta digital notebook component and associated aspects of the digital field data capture subproject of the SIGMA workflow.

All points raised during the testing period are shown, including problems for which solutions have subsequently been found (in conjunction with the developers and project management). As well as indicating areas that require further development, this report is intended to highlight aspects of the system that may require additional explanation during training.

Although this phase of testing was primarily intended to assess the beta notebook component of the digitally captured field data, aspects of this system were also considered for suitability with respect to the ongoing development of the digital fieldslip. Negative feedback directed at the notebook replacement may be due to the way in which users have attempted to force the notebook application to satisfy requests that would normally have been made of the fieldslip. This issue should be taken into account when considering the comments presented in this document. A detailed appraisal of the use of the GSD in visualising and manipulating these digital field data during this period is beyond the remit of this report, and will be reported elsewhere.

Following an overview of the test environment, detailed feedback on the “beta notebook application” and “geoline” tool is organised into three sections. Firstly, issues relating to pre-fieldwork office-based preparation are discussed. Secondly, field-based observations are reported. Thirdly, matters arising from the transfer and management of field data are described.

2 Preparation and field trials

The feedback presented here relates to a phase of testing undertaken during September 2004 in conjunction with the resurvey of the York area. One week of office-based preparation, including training, was followed by a two-week field campaign. In total, 3 survey staff were deployed with digital field data capture equipment (or “SIGMA Toolkits”). The contents of each toolkit are listed in Appendix 1.

The York field test area provides two distinct geological domains: lowland Quaternary (“Bedrock-free” Superficial geology with common Artificial Ground), and lowland Jurassic (“Superficial-free”, comparatively undeformed, sedimentary Bedrock geology with limited Artificial Ground). Each domain requires a different approach to geological mapping. Mapping in the lowland Quaternary domain relies heavily on auger data, soil observations, and an appraisal of historical topographic maps. Mapping in the lowland Jurassic domain relies on section logging, brush observations and sample collection. Extensive use of feature-mapping techniques is used in both domains.

Prior to commencing the field trials, formal office-based training was provided by development staff. The purpose of the training was to ensure that the staff involved with the testing were sufficiently confident with the notebook application and data transfer between the Personal Digital Assistant (PDA) and laptop. Other issues discussed during training included the customisation of dictionaries and data preparation requirements.

Field based trials were carried out from a single field base, allowing the testers to work together each evening, exchange data, and make use of shared hardware resources. In addition to 3 SIGMA toolkits, the field base was equipped with an A4 scanner, a dial-up Internet connection, and a colour A4 printer.

During the field trials, the notebook application development team and project management visited the testers to observe the field base and the use of the notebook application.

2.1 PRE-FIELDWORK OFFICE-BASED PREPARATION

- i. Prior to fieldwork, **it is estimated that approximately 4 man days were used in the preparation of data and installation of software, both on laptops and on PDA’s.** Approximately two days were taken to ensure that the software on both the PDA’s and laptops could operate successfully as “stand alone” and that the ActiveSync communication between the units was installed and functioning correctly. **Once set up, the system functioned efficiently and effectively.**
- ii. **As detailed in the training course and associated notes, the creation of a fully-populated ArcPad project is more involved than simply relying on the automatic “get data for ArcPad” functionality offered by ArcGIS.** It is important to emphasise the additional files and workflow required in setting up the data for ArcPad. This involves the successful installation of ActiveSync, and the separate transfer of raster images, Geoline, Geopoly and the Field_Geological_Record_Point shapefiles into the project.
- iii. **The file-naming convention for Historic Topographic Maps and scanned fieldslips does not provide a clear means of identification** in the restricted GIS table of contents available on a PDA. In order to identify which historic map should be displayed for a given area on the PDA, **an index shapefile should be created.** By querying the index

shapefile, the name of the relevant historic map can be displayed. An alternative is to activate each layer until the desired map appears, however this is inefficient.

- iv. **It is essential that all relevant sections of the Field_Dictionary are updated prior to commencing fieldwork.** This issue was discussed at length during training, and should be shown as a key stage in the SIGMA workflow or corresponding workflow document.
- v. **A significant performance gain (with respect to data transfer and ArcPad redraw speeds) was achieved by cropping the principal vector data to the area of interest.** DigMap50 Bedrock and Superficial themes were cropped in ArcGIS to each quarter sheet (+ 1 km buffer). The time spent preparing the cropped data in ArcGIS was negligible, and the improved performance significant (especially for the comparatively complex Bedrock data). This may be worth highlighting in the “notebook awareness” session of the formal training. Cropping the geological linework to the map limits could be done when setting up the initial GSD project.
- vi. **The successful installation of ActiveSync** requires sufficient administrator privileges, which may not be available on a pool laptop.
- vii. In the GSD2 training notes it is stated that **administrator privileges are required** to run the .bat file within the Object Class Extension folder. **When connected to the BGS LAN using a pool laptop, the user does not have administrator privileges.** It was therefore necessary to install the GSD logged onto the network using our own BGS AD domain user name and password, log off after installation and log back on using the pool laptop username (GroupID). Using the GroupID username, the .bat file could then be successfully executed. It should be highlighted that when a user does not have admin privileges there is no error message to indicate that the execution failed. If the GSD is run after installing using BGS AD domain usernames, a series of Visual Basic errors appear. It is suggested that this step be included in the GSD training.
- viii. **For the GSD to ascribe features to the correct user, the application must be executed under a user’s own session details.** This prevents users from executing the application when logged in under GroupID, as is often required when using pool laptops. The GSD (and other associated applications) should be revised to allow users to set the userid independently of the login id.

2.2 FIELD-BASED OBSERVATIONS

2.2.1 HARDWARE

The HP iPAQ h5500 series was used for field testing. This was loaded with ArcPad and the EVB application. The Fortuna GPS (Bluetooth enabled) was also used in conjunction with iPAQ. The Garmin eTrex, which is not equipped with Bluetooth, was also tested.

2.2.1.1 PERSONAL DIGITAL ASSISTANT (HP IPAQ H5500 SERIES)

- i. **The AquaPac provides a convenient and waterproof case for the iPAQ. However, when a reset is required, the case has to be opened, and the watertight seal is compromised.** Inevitably, this means that some moisture / dirt enters the AquaPac. Consequently, condensation can build-up, and the screen can become obscured. Whilst cleaning can be carried out later in the field-office, it is often difficult to do so in the

field, and the reduction in clarity can become frustrating. Silica gel was used in the AquaPac, and found to make a slight improvement.

- ii. **When the unit is suspended between observation localities, battery life is in excess of 12 hours. However, if the unit is used to navigate by, and therefore active throughout the day, battery life is insufficient.** Consequently, this unit cannot be relied upon as a fieldslip replacement, although this was never the plan. As described below, suspending the iPAQ also results in the loss of Bluetooth connections, and potential system instability. The h5500 iPAQ has a removable battery so an additional one could be supplied with each toolkit to extend battery life and avoid the need to suspend between sites.
- iii. **Training clearly stated that the iPAQ must be left on-charge when not in use (i.e. overnight, and weekends), otherwise data written to the internal memory (application and configuration data) may be lost.** Please could this point be emphasized, and can the recommendation be made that the reserve battery life (to maintain the internal memory) is set at maximum (72 hours)? Loss of the internal memory occurred on several occasions (due to user error). The subsequent process of resurrecting the software is time consuming and may require suitably skilled staff.
- iv. It appeared that data was stored in two locations on the iPAQ *i.e.* that field data was duplicated in the main memory and in the storage card. While this may be a function of the way in which the user configures their workspace, any ambiguity results in uncertainty, and reduces the user's confidence in the system. It appears that Windows "mirrors" the file structure so that each file appears to exist both in the main memory and the storage card, but all the data is still held only on the storage card. This should be clarified in the training course.

2.2.1.2 GLOBAL POSITIONING SYSTEM (GPS)

- i. **Bluetooth GPS can improve the "user experience" significantly.** When this technology is working well, the geologist benefits from the "auto-pan" functionality and the ability to see the current position at all times (especially useful when referring to Historic maps or non-topographic datasets). This changes the way the geologist works with the system, making it much more accessible, and far more of a mapping "tool". The lack of cabling allows the geologist to stow the GPS in their rucksack, freeing-up a hand.
- ii. **The Bluetooth GPS's were easy to set-up and configure** for use with the iPAQ and ArcPad.
- iii. **The Fortuna GPS was usually able to establish an accurate fix quickly** (more so than the Garmin eTrex). Furthermore, when used in moderately wooded areas, the Fortuna GPS was able to pick up more satellites than the Garmin eTrex, and provide a more accurate fix. However, one of the Fortuna units often struggled to get a fix, and frequently took several tens of minutes to do so – this unit was assumed to be faulty.
- iv. **The Fortuna GPS felt fragile**, and may not stand-up to the wear-and-tear of fieldwork quite as well as the Garmin eTrex.
- v. **The Fortuna GPS (or alternative Bluetooth GPS) would benefit from a key-lock function.** As the unit is used throughout the day, and stowed in a rucksack, the buttons (including on/off) are easily pressed by accident.
- vi. During testing, a **battery-life indicator could not be found on the Fortuna GPS.** The unit does have a visual indicator for low battery status, but this does not offer the

flexibility provided by the on-screen-display style battery-life indicator featured on the Garmin eTrex.

- vii. **Battery-life for the Fortuna GPS was limited** to less than 8 hours when running from a fresh set of batteries (both alkaline and rechargeable batteries were tested). This is significantly less than the Garmin eTrex (more-like 12 hours), and insufficient for a full day of fieldwork. Furthermore, the GPS requires batteries in sets of 3. This means that 2 chargers and 6 rechargeable batteries are required for a full days use, assuming that the batteries are changed at lunchtime. Combined with the lack of comprehensive battery-life indicator, this makes “battery management” difficult.
- viii. It was noted that **interference could occur when multiple GPS receivers were used close together**. Similarly, unwanted Bluetooth (and iPAQ-to-iPAQ) connections could be established if users operated too closely together. Often, this would mean that users were unable to re-establish a connection to their own GPS for some time. This is probably an inherent OS issue, rather than a problem with ArcPad.
- ix. A more serious issue is that the **GPS connection is lost each time the iPAQ is suspended between observation locations**. The connection has to be explicitly re-established each time the iPAQ is reactivated. Unfortunately, the process of losing the connection and re-establishing the connection often resulted in system instability, and the need to reset the system (up to 4 times in 1 day). Although this does not result in data loss, it is frustrating and means that the AquaPac must be opened to access the reset button, allowing the ingress of moisture and dirt.
- x. System **instability often resulted when the GPS signal was lost**. No definite pattern of instability was recognised, although attempting to access ArcPad’s GPS tools following signal loss may be to blame.

2.2.2 SOFTWARE

Each iPAQ was installed with ArcPad version 6.0.3 and the Encapsulated Visual Basic (EVB) notebook application. These were installed through ActiveSync. A customised toolbar was added to the ArcPad front end from which buttons creating and utilising the GeoLine and GeoPoly features were held. The toolbar also held a button to create the “Field Geological Observation Point” record that opened a form designed to hold index level information about the location and the project and user collecting the data. From within this form the EVB application could be fired up to record more detailed information about the site. The EVB application was designed to replicate the geologist’s notebook, whereas the Geoline and Geopoly tools were designed to represent the pencil linework on the current analogue Fieldslip.

2.2.2.1 ARCPAD INTERFACE AND INDEX LEVEL INFORMATION FORM.

- i. **It is too easy to set the wrong map area** in the drop-down menu in the Index level forms. A resolution to this issue should be provided by automatically calculating the map area from the grid reference.
- ii. The **notebook application allows index level information to be recorded independently of a related entry in the digital notebook, but this should be emphasized**. This issue may relate to instances when the user wants to record a simple “geographic note” (say a comment on a potential exposure, or a logistical note regarding land access – both of which are valid points that may traditionally be recorded in the analogue notebook). Clarification is required with respect to this point to avoid ambiguity. This location information can be recorded at the index level, or as a tagged-text comment after progressing to the notebook application. The field in the index level is purely for location information and will be tagged as such; additional tags must be

accessed via the comment forms. The usage of the text at the index level should be explained further during formal training.

- iii. The lack of **vector-theme transparency** can make working with complete vector coverage difficult. Coloured DigMap data could not be viewed in conjunction with topography. The user is able to work around this problem either by alternately displaying the geological and topographic data or by using an unfilled polygon layer and using the query tool. This issue will have to be resolved if ArcPad is to be considered as preferred application for the fieldslip replacement. ESRI claim that the next version of ArcPad will feature polygon transparency.
- iv. In the absence of Bluetooth GPS control, some users initially found that **accurately positioning a point on-screen was difficult** using the stylus. Consequently the solution in the field was to create a blank point layer called “Geography” whose coordinates could then be read from a non-Bluetooth GPS and manually entered. The resulting point was then used to reference and digitise the digital notebook point. Although this approach serves as an effective workaround, it still does not guarantee getting the point in the right place. Therefore, the use of a Bluetooth GPS is recommended. With familiarity of the system, this issue became less of a problem. New users should be made aware of the “learning curve”, and be reminded that that appropriate use of the zoom controls can effectively improve the accuracy with which points are located. This is important to ensure the accurate recording of the point in locations such as the corners of fields or the sides of roads where the GPS location may indicate a point up to 5m away. **Additionally, the user should be given the opportunity to reposition a point and manually update the position via the X and Y fields of the index-level dialogue box.**
- v. At the time of testing, **when adding an observation point using the GPS** position (as opposed tapping on the map window), the **location information did not automatically populate** at the index-level, or pass to the notebook application. This problem was discussed with the notebook application developers, and should be comparatively easy to resolve.
- vi. **It is important that the project code is easy to set up, but not to change.** It is suggested that the interface (or dictionary?) be modified so that this attribute can only be changed by a specific action (for example, setting the project code via a button, rather than a drop-down list).
- vii. Following completion of index-level information, the user must select “Open Notebook” to progress to the notebook application. Selecting “OK” from the index-level dialogue box (rather than “Open Notebook” results in the appearance of a dialogue box asking “Are you sure you don’t want to add data into the Notebook?”. This is counter-intuitive, as most PC applications require the user to use the “OK” to progress. Unfortunately the **interface cannot be modified to make use of the standard “OK” or “X” (cancel) buttons** as Microsoft will not release the code therefore the user needs to improve familiarity with the PDA system.
- viii. **The notebook application cannot be used effectively to review data.** The testing team acknowledges that this aspect of the application was not finalized at the time of testing. However, if users are to feel confident that their data is being securely recorded and accurately represented by the digital notebook, it is essential that user-friendly data review functionality is provided. Ideally, data should be accessible to the user via the map interface (i.e. selecting an observation point with the identify tool, or selective point labelling), as well as via the notebook application itself (i.e. through lists or searches). Users should be presented with a choice of data review formats including flat-file summaries and automatically repopulated notebook entries (i.e. returning the data to users in the same format as it was collected). Advanced data review options such as graphs, charts and graphic borehole logs would also be of benefit, and would provide an

additional justification for the wider acceptance of this technology. This weakness is being addressed by the developers and is a function of the complex multiple one-to-many relational aspect of the data being collected. There is no CE database that competently stores one to many relationships and so these relationships have to be hardcoded into the .cdb database. Any review or edit of this data also requires complex hard coding.

- ix. **The notebook application cannot be used effectively to edit or manage data.** The testing team acknowledges that this aspect of the application was not finalized at the time of testing, and that the request to edit data may be in conflict with the wider data management remit of this project. However, the testing team unanimously agrees that the ability to edit ones own data is essential if this technology is to be used effectively. The data edit functionality must allow obvious mistakes to be corrected immediately in the field, and additional data recorded within the context of an existing observation. The approach to data editing suggested by the notebook application developers (adding a new observation at the same locality that supersedes or supplements the original observation) differs too drastically from the conventional analogue approach. In practice, this can result in confusion whilst collecting the data, and difficulty when processing or reviewing the data. This method of working would require a list of errors that have to be corrected manually after the data is downloaded to the laptop; this is not practical. Consequently, users may be reluctant to correct mistakes, or add pertinent afterthoughts, and the quality of the field data may suffer. Users will be reluctant to use this technology if a user-friendly and intuitive data editing functionality is not provided. Ideally, the data editing functionality would be implemented in a similar fashion to the data review functionality described above (i.e. access via the map-window or the notebook application, offering users with a choice of either flat-file summaries or repopulated notebook entries). This is acknowledged as a fundamental weakness of the beta system and it is being addressed by the developers. The problem is a function of the complex one to many relational aspect of the data being collected and the fact that there is no database that competently stores one to many relationships on a windows CE device. Hence, these relationships have to be hardcoded into the .cdb database. Any review or edit of this data also requires complex hard coding.

2.2.2.2 ENCAPSULATED VISUAL BASIC NOTEBOOK APPLICATION

- i. The **notebook application can be used effectively to record (input) inherently structured data.** This phase of testing has shown that the application is well suited to the capture of auger hole information, section descriptions, photographs and sample data. Consequently, the application largely satisfies the requirements of a digital notebook replacement for recording data.
- ii. One shortcoming of the interface is that only vertical sections can be collected. **Traverse or ditch sections may constitute horizontal sections.** Consideration should be made to allow the capture of structured information along a vector other than the vertical (for example, a line or at least to point A to B with co-ordinates). A traverse could be recorded using the Geoline tool linked to a sketch and a series of sections – this suggestion will be evaluated.
- iii. Performance permitting, **real-time data validation should be enforced** on specific data fields. This will improve the quality of the digital data, and help mitigate against system instability (throughout the data capture / extraction / visualization workflow).
- iv. The **notebook application does not appear in the list of “running programmes”.** Consequently, the application cannot be switched to or terminated if a problem occurs. Could the application be listed? NB. This comment was discussed with the notebook application developers in the field, and it was pointed out that the application bar could

be used to swop between running programmes”. This satisfies the requirement, and should be made clear during formal training and in the documentation.

- v. **ArcPad seems to be “unaware” when the notebook application has been fired-up.** This can result in a Notebook entry being left open between localities. Consequently, when the user attempts to add a new Notebook entry, the Notebook application displays the incomplete proforma from the previous locality. This is confusing, and can reduce the user’s confidence in the system. The same issue is true of the Sketch Tool (i.e. a sketch can remain open, even though the Notebook entry for the locality has been closed). A possible solution would be to “lock” the parent application until the daughter application has been closed.
- vi. The notebook application user interface is generally intuitive and self-explanatory. However, **several field names and button labels could be changed to avoid potential ambiguity.** Following the addition of a comment, the user is presented with options to "open", "save", "done". In the absence of context-sensitive help or tooltips, the user may inadvertently select the wrong option. Although warning messages do appear to warn the user of any potential loss of data, ambiguous functionality may reduce the user’s confidence in the system.
- vii. When deleting a colour record from the colour category, a “record deleted” dialogue box appeared. This behaviour was unexpected, and the user unsure of the consequences of their action. The content of this (and perhaps other) **dialogue boxes will be reviewed to ensure a meaningful message is passed to the user,** possibly including an option to cancel their action and avoid a potentially frustrating loss of data.
- viii. **During testing the following error message was reported** when adding comments (possibly in excess of the field length?) via the section logging (auger) interface: “an error was encountered while running this programme a littoral value in the command overflowed the range of the type of the associated column”. The data entered by the user was lost.
- ix. **During testing the following error was encountered:** The weathering button in the unit descriptions for auger information did not work.

2.2.2.3 DATAMODEL/ DICTIONARIES OBSERVATIONS

- i. **Lithology and, where possible, lithostratigraphical attributes of auger and section data should be constrained** by the appropriate corporate dictionaries (“RCS” and “LEX”, or equivalent). This request was discussed with the notebook application developers, and is being investigated.
- ii. **Users request clarification on the implementation of lithological and lithostratigraphical codes and dictionaries.** For the purpose of export, edit, and review, lithology and lithostatigraphy data should be available in both code and full-text form. The same applies to other dictionary-constrained data. For example, a dictionary-constrained lithology drop-down list may show the full-text description for each option (“sandstone”, “mudstone”, “limestone” etc), however, the underlying database should record the code for the selected option (“sdst”, “mdst”, “lst” etc). This approach would make data management more straightforward for the user, and improve the compatibility between digitally captured field data and the existing corporate databases (i.e. Borehole Geology) and applications (i.e. GSI3D). the data model
- iii. Users requested the option to provide a **lithological (and lithostratigraphical?) description for the coarse clastic component** of a deposit. Primarily, this would apply to gravels, but may also be applicable to conglomerates, agglomerates, xenoliths etc.

- iv. **Bedrock lithologies and superficial lithologies should be described via different input methods.** Bedrock lithologies could be entered via a simple dictionary constrained drop-down list (“RCS”, or equivalent). However, the complex and potentially large number of superficial codes (constructed using appropriate combinations of Z-C-S-V-L-B-P) requires a different approach to data entry. Users suggest that 5 one-character drop-down lists are used (The corporate lithology database is restricted to 5 characters) Validation would ensure that the same character was not entered twice, and that no internal spaces were used. This would allow the user to construct any valid superficial deposit code. For each unit, the user should be given the choice of input method. This approach would facilitate the recording of interbedded Superficial lithologies and certain “Bedrock” lithologies (e.g. tufa, or shell-beds) for which codes are available. This can be implemented in the field data model once the dictionary is corporately approved and published.
- v. **The “environment of deposition” dictionary (for section unit description) may be unrepresentative** for all areas. Specifically, no entry was available describing “fluvio-aeolian” conditions. This issue may be resolved by each project establishing and maintaining a set of dictionaries - as clearly explained during training. However, this issue highlights the requirement that users are given access to all potentially expandable dictionaries that exist within the application. Care must be taken in deciding if a dictionary defines an exhaustive or “frozen” corporate set of terms (such as colours, or grain-sizes), or if the set of terms is likely to evolve at any point during fieldwork or the duration of the project (such as environment of deposition). Currently there is no corporate “environment of deposition” dictionary so this must be created.
- vi. There is a **shortcoming in the dictionary that is loaded for the colour fields.** It is only a subset of the colour dictionary and is not ordered. There is the BGS dictionary Dic_BGS_Full_Colour which includes Munsell equivalents and the same dictionary Dic_BGS_Full_Colour_V which does not have the Munsell column. These have a header and 121 colours. It is suggested that the colour data is arranged so that the drop down gives the list in the order shown in the column FULL_COLOUR_DESCRIPTION If this is so it should be relatively easy to find the colours, their qualifier and lightness in the list. An alternative way could be to allow the main colour, qualifier and lightness to be selected, but constrained by the dictionary to avoid colours that do not actually exist in the Munsell notation such as White, blackish. It is recommended that the full dictionary be available in the field application and that it be ordered appropriately.
- vii. For auger (section data), **unit dimensions should be presented as either “interval number and interval thickness”, or as “from-to”.** The latter approach is commonly used for analogue auger descriptions, and relates directly to the convention used in Borehole Geology and GSI3D. Ideally, the user would be given the opportunity to define the unit dimension using either approach (Borehole Geology provides this useful functionality). It is recommended that surface sections should be set at thickness, but auger sections set as intervals.
- viii. **Data field lengths and data types needs to be reviewed.** Users noted that all comment fields should be increased to at least 255 characters, and that the “colour” description be changed from an integer field to allow decimal Munsell colour values. Fields should already be set at a minimum of 255. Testers to provide specific examples of fields that are shorter. If fields longer than 255 are required, it should be possible to append multiple fields.
- ix. In addition to the capture of structured “section” data (i.e. multi-unit observations), the **notebook application should be developed to allow the collection of structured point observations** (i.e. single-unit observations such as soil notes and brash descriptions). This type of observation would make use of the dictionaries and forms developed for the

capture of section information, but would be identified at the index-level as a point observation. In practice, users addressed this issue by using the section-recording interface to log a single unit of arbitrary (say 0.1m) thickness – this provided a satisfactory method for capturing the information using the fields provided by the application. The main limitation with this approach is that the observation (a brush or soil note) is held in a database designed for (and subsequently considered as) sectional information – this could lead to ambiguity when the field data are written to corporate “downhole” databases. It has been agreed that the digital notebook be extended to include structured point observations as noted above.

2.2.2.4 GEOLINE/ GEOPOLY TOOL

The “geoline” and “geopoly” tools for ArcPad were developed as part of the fieldslip replacement system, and are intended for use on a tablet-PC. This initial assessment of the “geoline” and “geopoly” relates their performance when installed on the iPAQ-based notebook system. Consequently the feedback presented here is not necessarily representative of the final and intended performance of the “geoline” and “geopoly” tools. The geoline tool allows users to select a linestyle, such as “superficial inferred”, from a drop down menu and draw that line on the screen. The geopoly tool operates in much the same way except that the polygon style chosen is not constrained by a feature type and thus, is determined by the user or project team. Both the geopoly and the geoline allow the user to label their feature.

- i. The Geoline/Geopoly Tool is a **straight-forward and intuitive** application that satisfies many of the requirements of a basic sketch-map.
- ii. For laterally-persistent lines, the tool is responsive, and works well. However, for short line segments (such as hatching, line ticks on form-lines, arrow-heads etc), the **delay following the termination of each line segment** can render the tool unusable. Possible solutions include redesigning the conventional line styles to account for the lack of responsiveness, or coding functionality that automatically applies ornaments to lines. As PDA processing power increases however, the responsiveness of the application should improve, and mean that this issue is no longer a problem.
- iii. When using the line function for drawing **lines across large fields the resultant line was very irregular**. When zoomed in to a scale good enough to get a fairly smooth line the field boundaries were not visible and thus it was impossible to put an accurate location on the line. This is not a problem in small fields and may be helped by the use of NEXTMap as a backdrop.
- iv. Drawing a multi-segmented detailed and accurate line can be difficult, as the **tool attempts to join discreet segments** if the stylus is moved too slowly. The developers will investigate whether the “auto-join” functionality can be disabled to avoid this problem, or enabled via a tick box if required elsewhere.
- v. **The persistent line label option means that lines are often attributed with an inappropriate code**. Rather than presetting the line label from the drop-down menu, the developers will investigate whether it is appropriate for a line to be labelled when it is completed.
- vi. When used to describe geomorphological features, the Geoline tool may benefit from a **drop-on text mode to add common words like "flat" or "steepens"**. During testing, this information could be recorded as a labelled point observation, using the free-text comment field to hold the desired text. However, this approach was time-consuming, and required each point to have an associated entry in the notebook application. This is a feature that will be investigated in terms of the digital fieldslip.

- vii. The Geoline Tool **has been designed to show “corrections” in red**. Another colour such as green could be used to indicate a feature that is “rejected” but users will discuss whether it would be easier to cross out a line using the existing red line rather than introducing a new colour and linestyle.

2.3 TRANSFER AND MANAGEMENT OF FIELD DATA

- i. Wherever possible, **automation of the data management process should be developed**, or the “data cycle” documented in a user-friendly and comprehensive fashion. The testing team acknowledge that this aspect of the system was under development at the time of testing. However, for wider deployment, the process must be reviewed and streamlined. If possible, much of the file transfer, data conversion, and housekeeping should be hidden from the end user. The number of steps should be kept to a minimum, and the number of applications required to achieve this should be limited to one or two commonly used corporately supported applications (How many field staff are comfortable using Microsoft Access?). Ideally, the entire data management process should be available to the user via ArcGIS. A flowchart has been established for the daily transfer of data between the iPAQ and laptop (Appendix 5). The acceptability of this flowchart should be confirmed by the notebook application developers.
- ii. A range of PC-based **tools should be provided to allow users to visualise and manipulate their digital field data, or export their data for use in existing modelling and visualisation applications**. Wherever possible, any complex or lengthy data management or data processing operations should be abstracted from the user. As stated above with respect to the “data cycle”, the number of applications required to achieve this should be kept to a minimum. Ideally, a single interface should be developed (perhaps via ArcGIS?) providing all of the necessary functionality.
- iii. **A step-by-step workflow has been established for the daily transfer of data between the iPAQ and laptop** (Appendix 4). At the end of each day, users uploaded their digital fielddata file (FIELDLOG_2) into the personal databases, along with daily FGOP, Geoline and Geopoly shapefiles. Each of these 3 files was then uploaded into the GSD2. A blank FIELDLOG_2 database was copied back onto the iPAQ to use the following day.
- iv. No noticeable performance loss was noted when users retained the same field data files (FIELDLOG_2, Geoline and Geopoly) over subsequent days of fieldwork. However **office-based testing should be conducted to objectively assess the effects of large file-sizes on performance**.
- v. When copying the blank FIELDLOG_2 to the iPAQ it is important to confirm the path, otherwise the file is copied to a default location. The development team should test this aspect of the application, as **there may be a problem whereby data is not always copied to the named location**. The testers consider the file management process to be clearer if the FIELDLOG_2 file is deleted from the iPAQ first, rather than trying to replace it.
- vi. Users enquired **why is the fieldlog file named FIELDLOG_2, why not simply FIELDLOG?** This naming convention could cause confusion for new users of the system but as it is currently hard-coded into the system it will be explained as part of the formal training.
- vii. It was noted that fields in the **structural data table in FIELDLOG_2 seem to swap during the import process** to the laptop-based fielddata file (e.g.

FIELDLOG_2SPRICE). In one instance a dip value was incorrectly placed into the “plunge” field. The developers will attempt to recreate this bug and account for it.

- viii. **Problems were encountered when attempting to convert images to MrSID format using the ArcGIS export tools.** The development staff suggested a possible solution to this problem. However, this required relatively advanced knowledge of the software, and may not be a practical solution for all users. At present, it is therefore important that all raster files are prepared in the office, prior to commencing fieldwork. This is a significant limitation, as users cannot scan and visualise new documents (including current fieldslips), whilst in the field. An alternative method in ArcGIS is being tested to create MrSID files, which should solve this issue.

2.4 GENERAL ISSUES

- i. **It is important to maintain the distinction between the two components of digitally captured field data – the notebook replacement, and the fieldslip replacement.** Negative feedback directed at the notebook replacement may be due to the way in which users have attempted to force the notebook application to satisfy requests that would normally have been made of the fieldslip. This issue should be taken into account when considering the comments presented in this document.
- ii. The workflow **documentation and training will be updated with graphical representations of the data flow**, to assist the user when in the field. A first-pass attempt is included in Appendix 4 and Appendix 5. The graphics should show filenames, applications used, hardware required, the purpose of the process, and the options available to the user at each stage. This approach may improve the eventual uptake of the system for which data preparation and transfer is the most complex part.
- iii. In the field-office, digitally captured field data management and digital map creation methodologies carry a **significant additional workload** with respect to conventional mapping practices. Whereas traditionally, the geologist would return to the B&B each evening and spend a short time “inking-in”, the use (and availability) of digitally captured field data and technology means that many hours can be spent managing and appraising the day’s data, and preparing the system for the following day. **The team typically spent 1 hour from 8:00AM preparing hardware and data, and from 6:00 PM until 8:00PM transferring and assessing the days’ data (assuming that each geologist had access to a dedicated laptop).** The team acknowledges the downstream benefits associated with these practices, and understands that the workflow under development will become more streamlined as it evolves. However, this workload may be inappropriate over a significant length of time, and staff that prefer to work from “9 to 5:” will undoubtedly protest. Possible solutions include: returning to the field-office earlier each day (although this can be hard to justify when you are spending Other Recurrent for the purpose of observing and collecting field data, and you may have spent a significant amount of time accessing an area); scheduling one day each week to work with the digital data (this approach may preclude daily backups, and would mean that data is not available for immediate appraisal); providing tools that improve the efficiency of data management and appraisal, and ensure that each geologist has access to a dedicated laptop (this is the preferred solution, that would maximise efficiency and maintain a rigorous approach to data management).
- iv. The system and speed of data transfer during this phase of testing has highlighted the requirement that each geologist involved with the SIGMA workflow has use of a **dedicated laptop**. The team had initially planned to work with 1 laptop for every 2 geologists. However, in practice we found that laptop sharing was inefficient and frustrating. All stages of field data preparation, transfer and appraisal rely on the use of a

laptop. Scheduling a rota is not practical, as few tasks are possible without access to digital data. On this occasion the team of 5 were fortunate in having access to 4 laptops (a combination of project and pool laptops). This proved workable over a short period, but would be unsustainable over any significant length of time unless data transfer is substantially streamlined.

- v. Geologists often use informal (and highly personalised) shorthand words and phrases when describing field observations (e.g. “sm. exp. v.w.sort o.m v.” for “small exposure of very well sorted oligomictic gravel”). The shorthand used by each user will vary, and each user may make inconsistent use of their shorthand (depending on the length of an entry, the complexity or emphasis of the description). **The limitations of textual entry using the iPAQ often results in a greater reliance on shorthand words and phrases, especially in free-text data fields. Consequently, the content of free-text entries cannot easily be developed in the digital environment. It may be inappropriate to force geologists to dispense with shorthand, therefore to facilitate the use of free-text within the digital environment, the use of tagged comments should be strongly encouraged.** Predictive text entry (c.f mobile telephone text messages) should also be investigated. A corporate “predefined predictive text dictionary” should be created and pre-loaded to all iPAQ units where applicable.
- vi. Whilst the data capture interface is well-structured, and makes the most of the limited screen-size, **using the system often feels like a database population exercise, and not an opportunity to record observations.** This issue is clearly subjective, however, if the “look and feel” of the system is too removed from the “pick-up and write” of the traditional notebook, then users may feel reluctant to record a quick observation or sketch and describe a panorama. Perhaps some aspects of the user-interface could be less formal, or graphical icons used in place of text labels? The resemblance to database population may not concern some users, but may distance others.

3 Conclusion

The notebook application allows and encourages users to record structured data as quickly, and in a more thorough way than the conventional analogue methods. The functionality to automatically locate observations and apply real-time data validation (via drop-down lists or otherwise) improves the quality of field data. The ability to reference the observation against a diversity of basemaps (via ArcPad) allows the user to consider a far wider range of baseline information when committing an observation. Together with a Bluetooth GPS, the system is relatively well suited to field conditions encountered in the lowland Quaternary and lowland bedrock terrain of the York area.

However, the lack of data editing, and data review functionality means that the system is not yet a practical replacement for the analogue notebook. Users were frequently frustrated that small (yet significant) errors in their observations could not be rectified. Re-entering an entire observation for the sake of a single error or omission is not practical. Similarly, users felt that the existing observations could not easily be reviewed. An immediate review function should be provided to allow user's to make use of their field data whilst in the field, and also to improve user-confidence that the data is intact and accessible. Together, the issue of data editing and review resulted in a general reluctance to record field observations using this system.

Field-office data transfer is logical, but would benefit from a better documented, streamlined, and largely automated approach. The users were often uncertain where their data was located, or if a transfer had taken place. Explicit confirmation (or otherwise) following each process would help improve user-confidence. The data transfer process should be integrated with data export functionality. Without appropriate export functionality and ease of data transfer into other applications, the principal downstream benefits (as far as the geologist is concerned) of digitally captured field data cannot be recognized.

This phase of testing has highlighted the advantages offered by the notebook replacement application, and has shown the key limitations of the current system. The team of testers was encouraged to find that data capture using this system could be as quick as when using analogue methods. However, wider acceptability of the digital notebook depends on the additional functionality of data edit and review. Similarly, the real benefit of digital field data capture, and the justification for the additional time users will need to become familiar with the system, will only become apparent when user-friendly data export tools are developed.

The Geoline and Geopoly tools work well in many instances, such as when sketching long continuous lines. However, for shorter or annotated lines, the Geoline tool is not sufficiently responsive to allow conventional symbology to be used. Alternative symbologies may be required, however issues relating to the limitations of these tools and the fieldslip replacement should be considered independently of the notebook application that was being tested in this phase of trials.

4 Recommendations

A prioritised list of requests based on field trials in York is shown below. The main body of this document provides an explanation in support of each request, and a range of potential solutions. This list is not intended to be comprehensive; rather, the feedback presented in this document is intended to raise discussion and allow a more complete list to be developed.

1. **Data edit functionality (in the field)** – without this level of control over their data requirement, users may be reluctant to use this system. Consider offering a range of report styles including a re-populated data-capture interface, flat file, ArcPad dialogue box.
2. **Data review functionality (in the field)** - report styles as above, including graphical logs / sections where appropriate. This should also include consider the way in which ArcPad can be used to label points – ideally based on data held in the underlying notebook application database.
3. **Streamlined data-transfer process** – automated where possible, documented graphically, not requiring users-knowledge of multiple “advanced” applications.
4. **Data export functionality** – a suite of user-friendly tools should provided to allow digitally captured field data to be extracted in a range of standard formats (flat-file, GSI3D compatible, shape-file etc) for seamless transfer into standard modelling / visualization packages. Where possible, data should be recorded in codified form to improve export compatibility and eventual transfer to corporate databases.
5. **Investigate alternative Bluetooth GPS solutions** - to fully appreciate the system, and maximize productivity and usability, Bluetooth GPS is essential. However, - the Fortuna GPS does not offer the battery-life, key-lock or build quality that are required.
6. **Section interval defined by “thickness” or depth “from-to”** – consider the range of data entry options offered by Borehole Geology.
7. **Provide improved functionality for the construction of Superficial Deposit** codes based on the Z-C-S-V-L-B-P convention.
8. **Provide point data capture functionality** – allow the established proformas and dictionaries to be applied to single-unit observations such as soil or brash descriptions.
9. **Traverse section functionality** – allow sections to be defined horizontally as well as vertically.
10. **Develop vector-theme transparency** – to allow both DigMap and topographic data to be visualized together (possibly a fieldslip-replacement issue, however this does affect the way in which the notebook application is used).

Appendix 1

SIGMA TOOLKIT CONTENTS

Protective (padded) “toolkit” case

PDA – HP iPAQ h5500 with docking station and data cables

iPAQ 12V recharge cable (NB. Not all pool vehicles have cigarette lighters)

512Mb SD memory card

PDA protective case - AquaPac

GPS – Bluetooth

Digital Camera with XD card, spare battery and carrying case

Media card reader / writer

A4 colour scanner

A4 colour printer

AA and AAA batteries and charger

Laptop and accessories

Appendix 2

Although not directly related to the notebook application, the use of “**strike-lines**” (or “stratum contours”) to model the geometry and distribution of a geological surface whilst in the field, and when assessing field observations in the field-office, is an essential part of field mapping. This functionality must be provided by the digital fieldslip. Without the ability to perform this kind of data appraisal, users will necessarily resort to the analogue environment. If appropriate functionality can be provided, the benefits of constructing surface models in the digital environment are significant. This opportunity should be investigated at the earliest opportunity, as the results may constitute **an additional selling point of the digital fieldslip** and digital map compilation. A review of an initial investigation into the digital construction of strike-lines using the GSD is shown below.

USE OF NEXTMAP IN PREDICTING BEDROCK BOUNDARY PROJECTION

The vale of York team used Nextmap extensively during the recent field campaign on the York sheet, and has also used Nextmap during map compilation on the Selby sheet. In both cases, the "raw" datasets used are as follows:

Nextmap ORI: data checked for each area, but found to be of little help in generating linework, or checking existing linework.

Nextmap DTM: data checked - both for the flat-lying drift-dominated areas and the higher-relief bedrock areas. In both cases, we felt that the cleaning algorithm (?) produced inconsistent, and inappropriate results. Consequently, this dataset was not used for generating 10k linework by visual inspection. However, this dataset has been used for cross-section work at 1:50k, where a more generalised surface model is acceptable.

Nextmap DSM: This dataset has been used extensively for 1:10k line generation on the York sheet, and for minor re-interpretation of selected areas on the Selby sheet during the final phase of edge-matching prior to map publication. A very good data resource.

The techniques used are as follows. Unless specified otherwise, the DSM was used. For completeness, this report lists new methodologies as well as standard approaches:

Colour slicing: Manipulating the colour scheme manually using ArcMap to highlight specific features. We also created new "repeating" colour ramps to visualise slight changes in elevation over a wide range of elevation. **Request:** could a "slider" tool be developed (that would sit on the active window) to allow the colour range to be adjusted "dynamically" without having to open the theme properties dialogue? **NB.** When applied to the low-relief superficial-dominated areas, the scale of the geological features often approached the vertical resolution of the data. In many cases the data "noise" was more apparent than the geology, forming a semi-regular pattern of waves. At worst, the waves attain an amplitude in the order of 2 m (perhaps more than the limits quoted by Nextmap?). On the bedrock-dominated areas, certain features that are clearly visible on the ground do not appear in the DSM - this may be a function of a particular flight direction and acquisition angle whereby low angle dip-slopes offer an extremely-low angle of RADAR intersection.

Hillshade: Using ArcMap to generate hillshade models to highlight specific trends. Multiple models were created by varying the azimuth and declination. These models were either visualised on their own, or used in conjunction with the colour sliced models.

Slope: Using ArcMap to generate and colour slope models. Colour slicing of these models was used to highlight specific features. Slope models were generated using the standard 5m cell-size, but also using 10, 15 and 20m cell-sizes in an attempt to smooth-out noisy data. The different models were combined using the transparency function of Arc to show the high-frequency slope-changes (5m cell-size), together with the more general slope trend (15 and 20m cell size). This technique was applied to the bedrock-dominated areas to identify breaks in slope. By combining these models with the hillshaded models, existing bedrock linework could be inspected (and scheduled for field-inspection if found to be incorrect), and new linework could be generated. Second order slope models (slope of slope) were also created and used in conjunction with the other models to further refine the automatic mapping of features. **NB. As described below, the slope angle technique, when used alone, does not allow the identification of several key geomorphological features - symmetrical crests and valleys!**

Aspect: Aspect models were generated using ArcMap to further assist linework verification and generation. Whereas slope analysis highlights changes in slope angle, aspect models were used to identify changes in the facing direction of slopes of similar angle (for example symmetrical valleys, symmetrical ridges, or plunging crests). Together with the slope and hillshade, aspect models allow a full 2-dimensional appraisal of the Nextmap DSM for the purpose of validating existing linework, and generating new 1:10k data. This is essentially what the work on "Synthetic Feature Mapping" has resulted in - **as you can see, it's nothing new, but if this approach could be documented, and even semi-automated, we think it would constitute a convenient tool.**

3D Drapes: Using ArcScene, 3D draping of geological linework over the **Nextmap DTM** has greatly assisted the **understanding, validation and modelling** process. Firstly, we were able to drape the existing York sheet linework to inspect the spatial relationships between units - this is an ideal way of understanding what the geology of a new area means prior to commencing fieldwork. This was applied to both superficial and drift areas. In the case of bedrock areas, we were able to identify principal structural features including unmarked folds. Secondly, we were able to use the draped linework to identify areas where the 3D geometry was obviously wrong - such as horizontally-bedded contacts V-ing up or down a hillside. Any problem areas would be targeted for field inspection. Thirdly, we were able to check our new geological linework for geometric consistency by scanning the fieldslips, draping, and rotating them in 3 dimensions. **Alternatively (and by far the most efficient way of doing this), we have performed an iterative validation of our new model by constructing our linework using the GSD2, passing the interim results to ArcScene, draping and inspecting, then make any changes directly in the GSD2 - could this be considered part of the GSD workflow?**

Automatic Strike Lines: By point-inspecting NextMap, we are able to determine an accurate elevation value to a field observation or outcrop. Since our fieldslips are scanned and "heads-up", it is relatively straightforward to create a shapefile (or GSD class) for all exposures of a particular unit, and automatically ascribe an elevation value. By gridding the surface defined by this array of points, we can create a surface for the unit. This is easily done in Arc. By inspecting the surface in 2D and 3D (using many of the techniques discussed above in the context of the DSM), we can identify irregularities and recognise the likely position of faults. **The resulting surface can also be intersected with the DSM or DTM (a simple calculation) to automatically generate the surface outcrop of the unit.** Arc even provides the functionality to include break-lines (i.e. taken directly from the fault feature class in the GSD) for a more consistent model. In modelling surfaces for the Chalk on the York sheet, and technique has been found to be far more efficient and accurate than manual construction of strike lines. Furthermore, A mini-application has been developed that allows the automatic generation of a planar surface for a given dip and strike observation. By following the workflow described above, this surface can then be used to automatically interpolate the outcrop line for the unit. **This tool has proved itself useful on the deformed strata of the York sheet. Could developer time be found bring**

the mini-application into ArcGIS, and to allow the creation of surfaces based on multiple structural observations?

Appendix 3

PLATES



Plate 1 - Field office (Stamford Bridge) showing evening working environment



Plate 2 - Field office (Stamford Bridge) showing evening working environment



Plate 3 - Section logging (Whitby) showing natural Bedrock exposure



Plate 4 - Section logging (near Malton) showing artificial Bedrock exposure



Plate 5 - Auger logging (near Stamford Bridge)



Plate 6 - Section logging showing artificial Superficial exposure

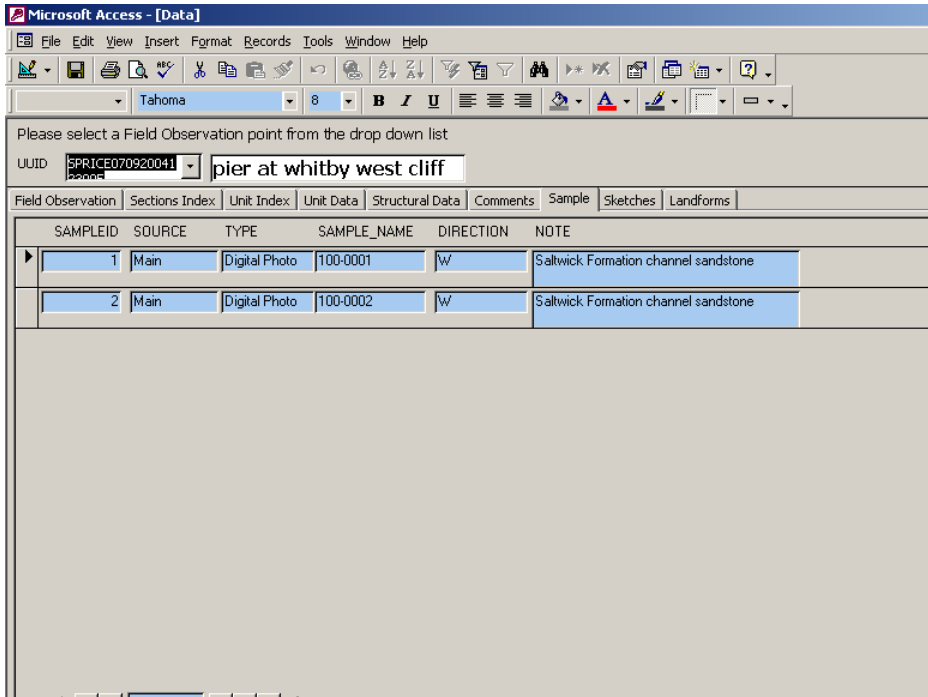


Plate 7 - Microsoft Access screenshot showing database entry for photograph

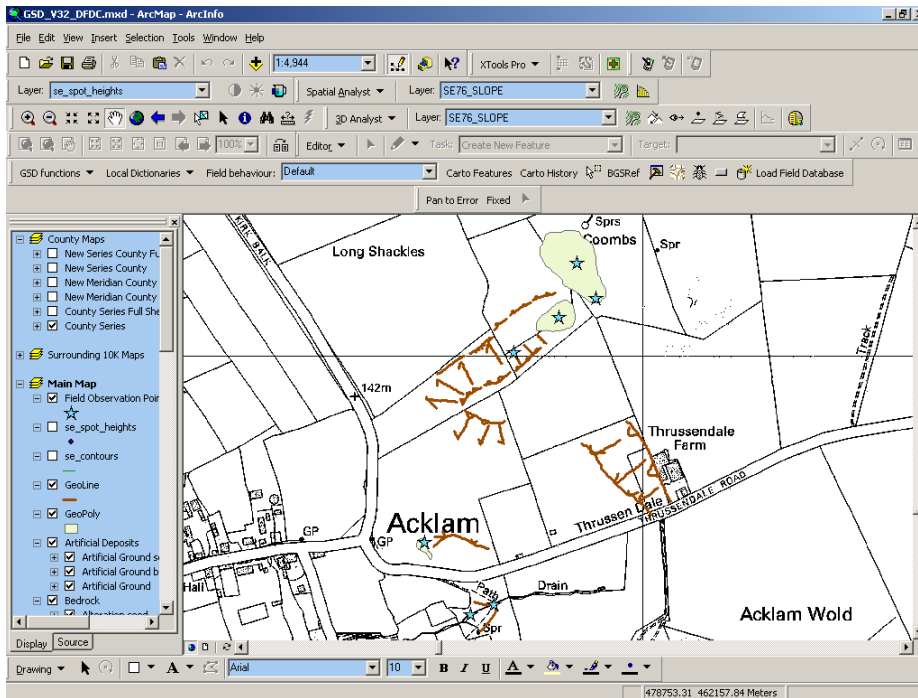


Plate 8 - ArcGIS (GSD) screenshot showing digitally captured linework and point observations

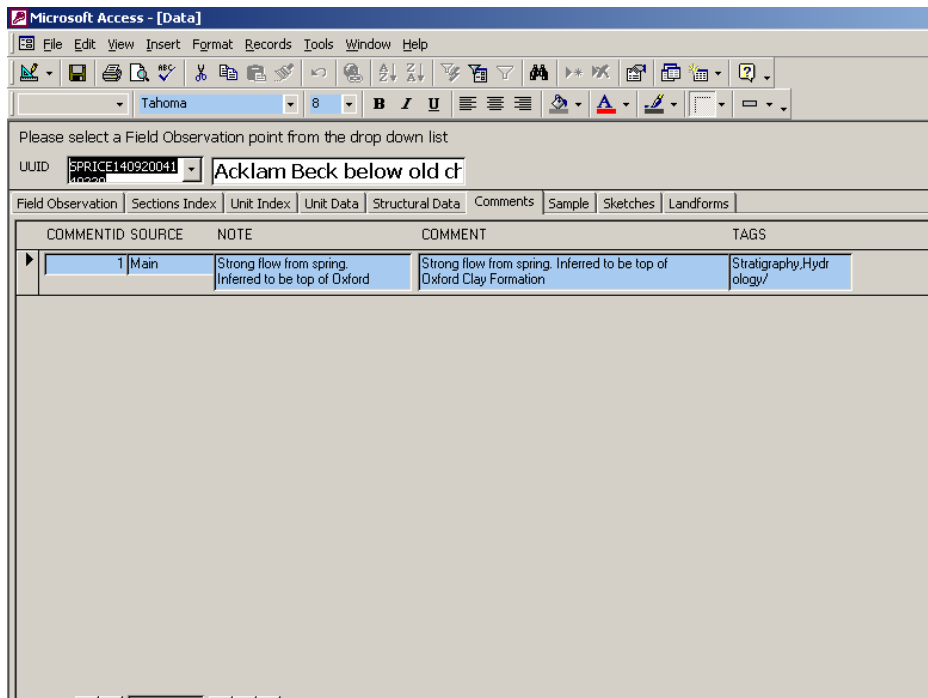


Plate 9 - Microsoft Access screenshot showing tagged text database entry (spring)

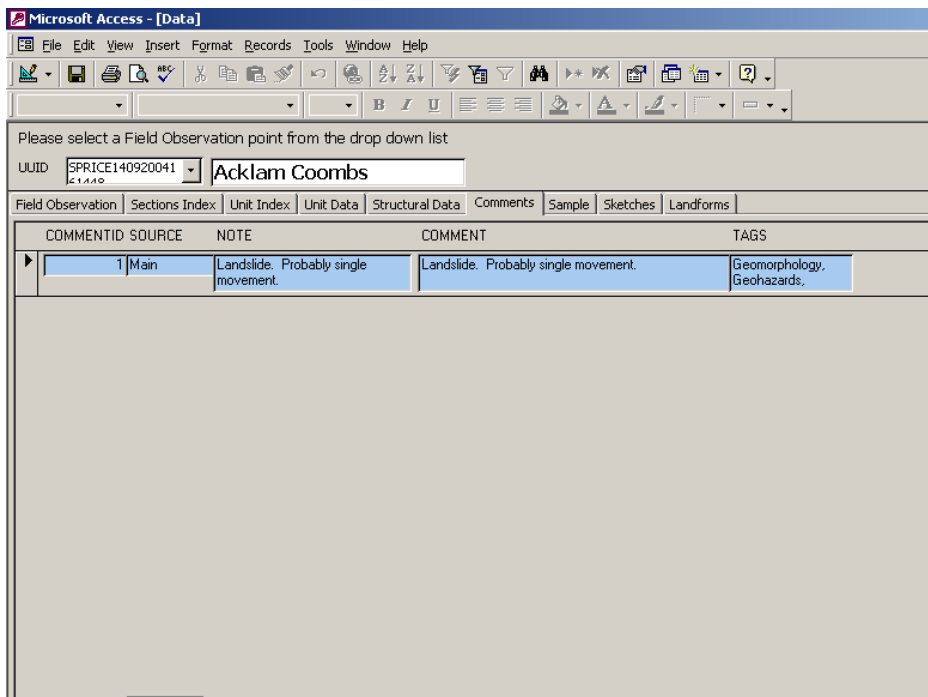


Plate 10 - Microsoft Access screenshot showing tagged text database entry (landslide)

Appendix 4

DAILY SETUP WORKFLOW

Quick Guide to the Daily Set-up Workflow for the SIGMA Digital Field Notebook – including daily backup procedure of FGOP, Geoline, Geopoly shapefiles

1. **Before going to field** – this step is only necessary once for FGOP and Geopoly and Geoline shapefiles but was repeated each day for FIELDLOG_2 and can be repeated for FGOP and Geopoly and Geoline shapefiles if you want to start each day with empty files.
 - a. Copy blank FIELDLOG_2.mdb to IPAQ memory card
 - b. Copy over blank FGOP and Geopoly and Geoline shapefiles
 - c. Ensure GIS is working correctly with all required data loaded
2. **Collect data**
3. **On return from field**
 - a. Copy FIELDLOG_2 from the IPAQ to laptop. Firstly copy to a backup folder and then to 'SIGMA_FIELDWORK_userid' folder. Replace existing FIELDLOG_2 file.
 - b. Copy over FGOP and Geopoly and Geoline shapefiles from IPAQ to a backup folder on the laptop
 - c. Make sure 'FIELDLOG_2_userid.mdb' file is in the same directory as the FIELDLOG_2 file.
 - d. Click on FIELDLOG2_userid.mdb
 - e. Go to Tools>Database utilities> linked table manager
 - i. Select all the tables
 - ii. When asked for location of the database to link to navigate to the location of FIELDLOG_2.mdb
 - iii. Now select 'Import'
 - f. Data from FIELDLOG_2 will be appended to FIELDLOG_2_userid.mdb.

Appendix 5

DAILY SETUP FLOWCHART

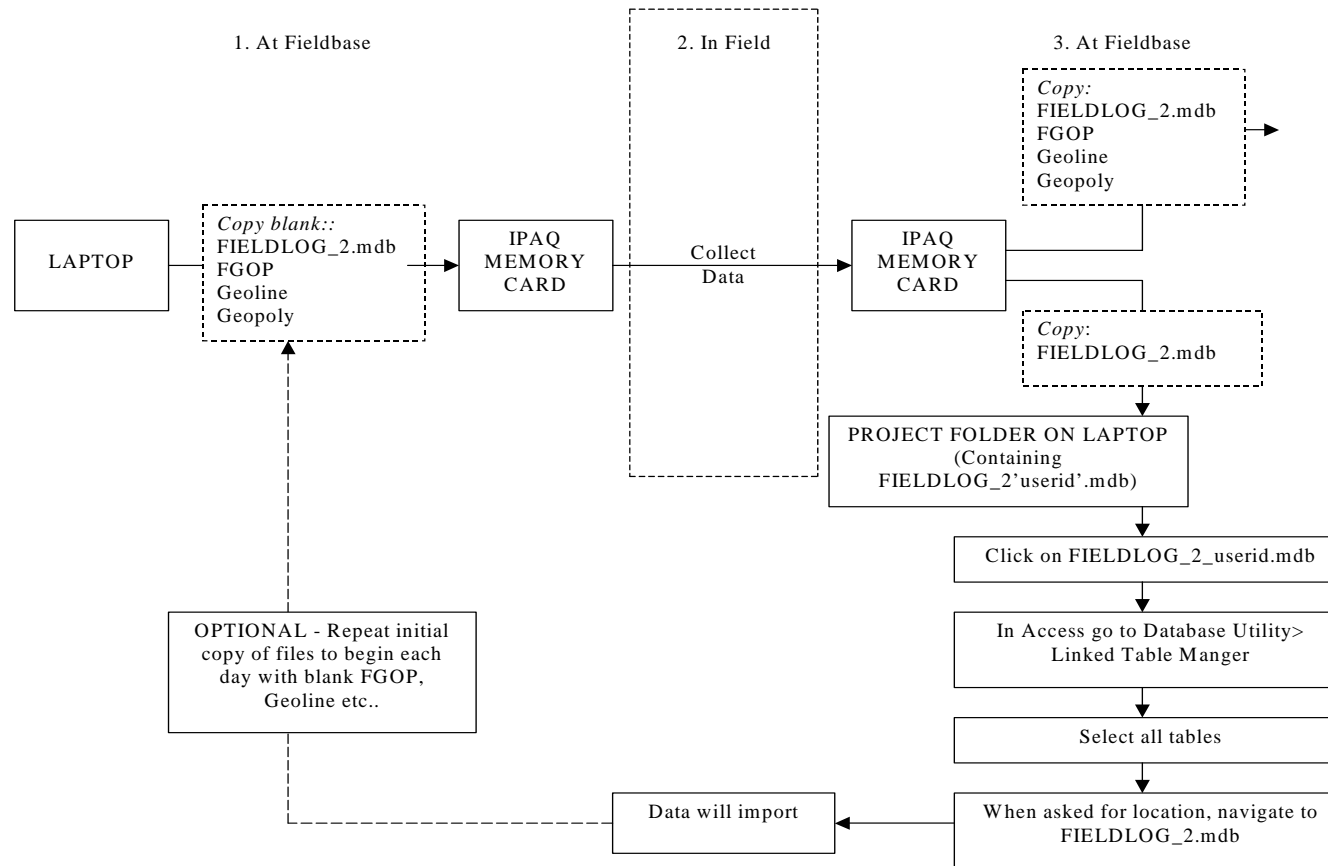


Figure 1 - Daily setup flowchart