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REPORT TO CYPRUS ANVIL MINING CORPORATION

COMPUTERIZED TECHNIQUES FOR GENERATION OF MINE BLOCK MODEL PARAMETERS FROM GEOLOGICAL SECTIONS

by J. R. Marlon-Lambert

4 June, 1980

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Page No.

FIGURES

LIST OF ILLUSTRATIONS - Continued

Page No.

TABLES

COMPUTERIZED TECHNIQUES FOR GENERATION OF MINE MODEL PARAMETERS FROM GEOLOGICAL SECTIONS

1.0 INTRODUCTION

Cyprus Anvil Mining Corporation is currently involved in detailed mine design activities for the Grum and Vangorda deposits within the Anvil district in the Yukon Territory. These deposits are composed of massive pyritic lead-zinc-silver ore zones within an extensively deformed and metamorphosed host rock environment. The ore zones are stratiform and stratabound but of extremely complex geometry as a result of several major and minor regional deformation events subsequent to their original deposition. The orebodies have been explored over the last two decades and recent feasibility studies indicate that the currently defined reserves may be profitably mined. Detailed geological modelling of the deposits was done by a manual process with the principal result being an extensive series of graphic interpretations on cross- and long-sections. A fundamental and initial task in the detailed mine design for these properties will be the transformation of geological data as it exists in graphical form to the computerized three-dimensional block model used to represent the proposed mines. This data transformation has previously involved manual interpolation exclusively and thus was tedious and time-consuming. This report presents basic concepts and operations that would be involved in a more automated data transformation process.

1.1 Background

This report was initiated as a result of discussions at the Grum Camp between Daryl Hanson, Peter Clarke and the author in early May, 1980. Review of the Vangorda property geological sections indicated to the author that considerable man-time and tedious labour would be involved in transforming the geological information to a format suitable for input to the Mintec MEDSYSTEM for preliminary mine design. This labour-intensive activity would also have to be repeated if a different set of bench elevations was to be considered or partially re-done if bench block orientation (or spacings) changed. After a review of the characteristics of this activity, the author developed the (conceptual) technique described in the report which could dramatically reduce the overall time and labour involved.

1.2 Purposes of the Report

This is an informal report to Cyprus Anvil with a primary and a number of secondary purposes. The primary purpose is obvious but a re-statement is useful, thus its primary purpose is:-

- to outline and define computerized techniques for the generation of mine block model parameters from geological sections.

This primary purpose is addressed specifically throughout the body of the report. The techniques and actual needs for them should be discussed within Cyprus Anvil with the view to either accepting or rejecting the overall concept. Should the techniques and the need for them be accepted, then a second round of discussions should take place to formalize the system's functional requirements, to approve and order any additional hardware or operating system software, to estimate applications software development costs, and then to authorize the programming effort.

The secondary purposes of this report are manifold but generally relate to the development and implementation of computing facilities for Cyprus Anvil's engineering activities. 'Engineering computing' is intended to describe the range of non-business data processing activities undertaken by the Exploration, Feasibility and Development, Engineering and Operations groups within Cyprus Anvil. First of all, this report is intended to initiate discussions within and between the groups indicated above, as well as with the Finance/Accounting group responsible for provision of computer services. It proposes a computerized technique for the solution of a common mine design problem which has implications for:-

- computer hardware acquisition,
- computer usage rationalization and coordination,
- computer resource management,
- computer software engineering, development and coordination,*
- computing facility administration and maintenance.

(*Perhaps the area in which there is the least understanding, direction and control at the moment.) Guidelines for the conduct of the above activities as they relate to engineering compute should eventually be formulated through the above inter-group discussions.

Secondly, the report indicates the need for acquisition (and development) of various hardware and software components for general engineering computing purposes. In the main, these components can (and should) be used as either utility machines (e.g. the plotter to be installed in Faro) or as utility routines (e.g. the general computer graphics subroutine package). To charge the cost of such general use components to one specific project or engineering group may or may not be reasonable, but some discussion should be initiated on this topic.

Thirdly, the report should make Cyprus Anvil personnel aware of the existence of the HP-3000 computers in the Faro and Vancouver offices. These machines were acquired for business (or commercial) data processing purposes but could be effectively used for many of the current engineering computing applications, as well as for future applications. They are mini-computers with limited memory, processing speed and data storage facilities when compared with many computer service bureaus. However, they do have an impressive potential for a wide range of engineering computing applications and rational (and increasing) use should be made of them.

Fourthly, the format of this report is intended as a prototype for engineering computing applications system proposals and commentary is invited. As the author is working on a number of computer systems development tasks for Cyprus Anvil, it is important to establish adequate and appropriate documentation standards, and this is an example of one form of documentation.

This report has been prepared as a draft document for comment by interested Cyprus Anvil personnel. Copies are being distributed to:

Mr. D. Hanson	- Feasibility and Development, Grum Camp
Dr. D. Jennings	- Chief Geologist, Exploration
Mr. J. Purkis	- Chief Engineer, Faro Operations
Mr. P. Clarke	- Engineering Geologist, Faro Operations
Mr. F. Clark-Jones	- Computing Liaison/Accounting, Vancouver

2.0 DEFINITION AND ILLUSTRATION OF TECHNIQUES

The generation of mine block model parameters from geological sections is a complicated and time consuming process currently involving much tedious manual labour on the part of the mining engineer or geologist. Typically, for a general property, this might involve two to three man-months effort which would have to be repeated if a different bench arrangement or block size is to be investigated. This report presents an overview of a proposed computerized technique to facilitate and automate many of the tasks involved in the mine model parameter generation process.

The proposed technique is essentially an 'interactive Computer Graphics Process' in that control and coordination of all computing activities is exercised by the responsible project geologist or mining engineer. (The small 'i' in 'interactive' indicates that the proposed technique involves non-automated man-machine interaction, i.e. computing activities will be segmented batch operations with geological control being exercised manually between the segments.) The process would be designed for and implemented on Cyprus Anvil's HP-3000 computers installed at the Faro minesite and the head office in Vancouver. The batch program segments would be organized to allow geologists and engineers to use the system directly and easily.

The overall process is a computerization of existing manual methods, and follows the normal step-by-step procedure that is current practice. The fundamental differences between the proposed system and the manual methods will be:

- retention (i.e. storage) of digital data representing geological information, and

- rapid production of cross-sections and bench plan maps (at a variety of scales, if desired).

The proposed system would be constructed from modular special purpose functions and thus could be readily adapted or enhanced in the future to take advantage of improvements in computing hardware and operating system software.

The operation of the proposed system is best explained at this time by an illustration of its use on a typical project. The remainder of this section is devoted to a step-by-step description of its application to a hypothetical and simplified property. The reader should note how the geological nature of this property is transformed from the original orebody model to the eventual mine model with the responsible geologist controlling all idealizations and simplifications.

2.1 The Orebody

The orebody used as the example bears a superficial resemblance to the Vangorda property. Figure 1 is a plan-view of the property indicating the general outline of the orebody and the locations of cross- and long-sections used in the geological modelling process. These sections are built up manually by direct geological interpretation and interpolation of surface outcropping, diamond drill core and geophysical data. A typical cross-section is illustrated in Figure 2. This is a much-simplified version of an actual geological cross-section but serves to illustrate the folded and faulted nature of the property. The actual mineralized region is stratiform and stratabound, as well as being highly metamorphosed. The property has been extensively eroded and subsequently overlain with additional sedimentary material which has different geotechnical properties from the host rock types.

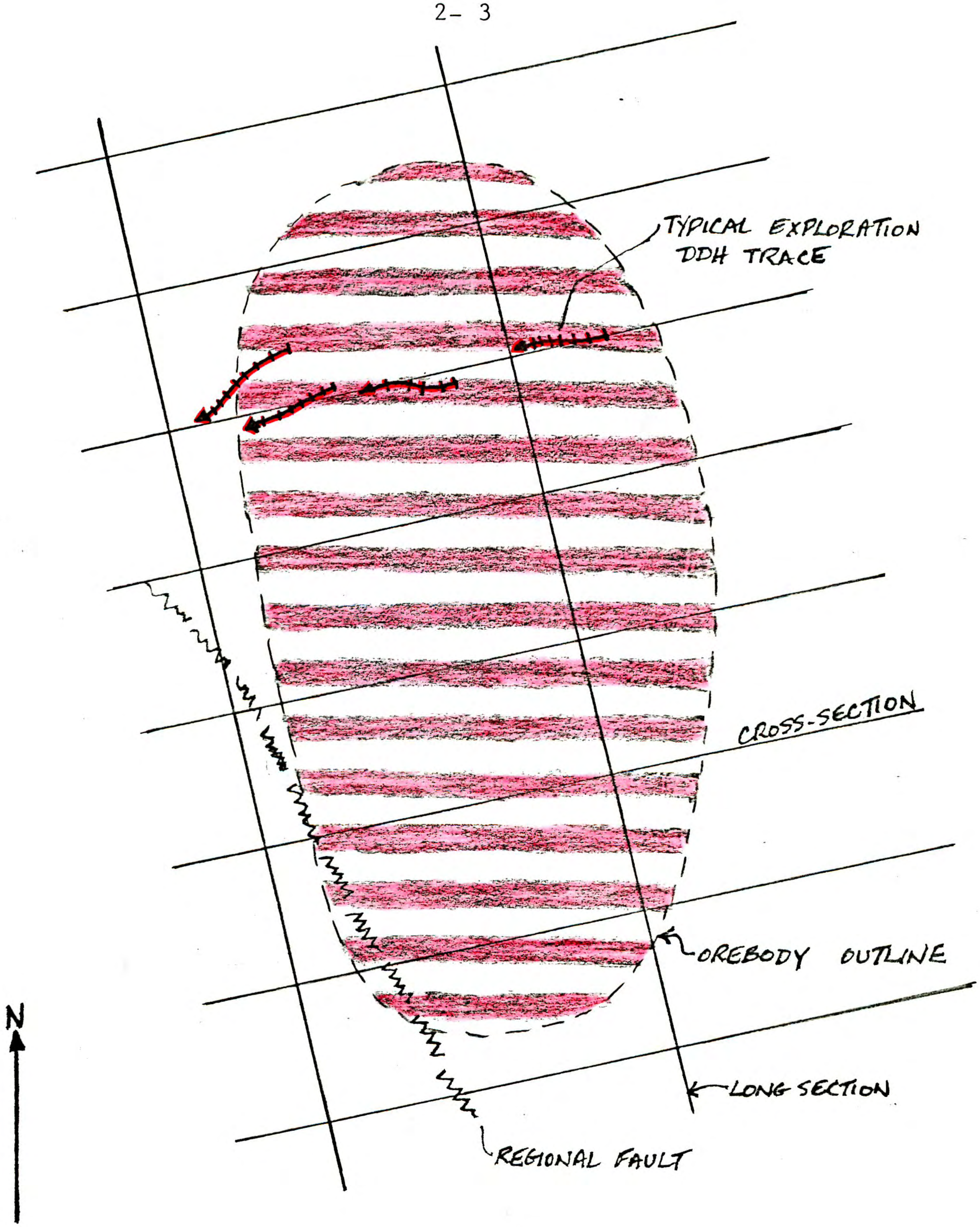

Figure 1 PLAN-VIEW OF PROPERTY TO BE DEVELOPED

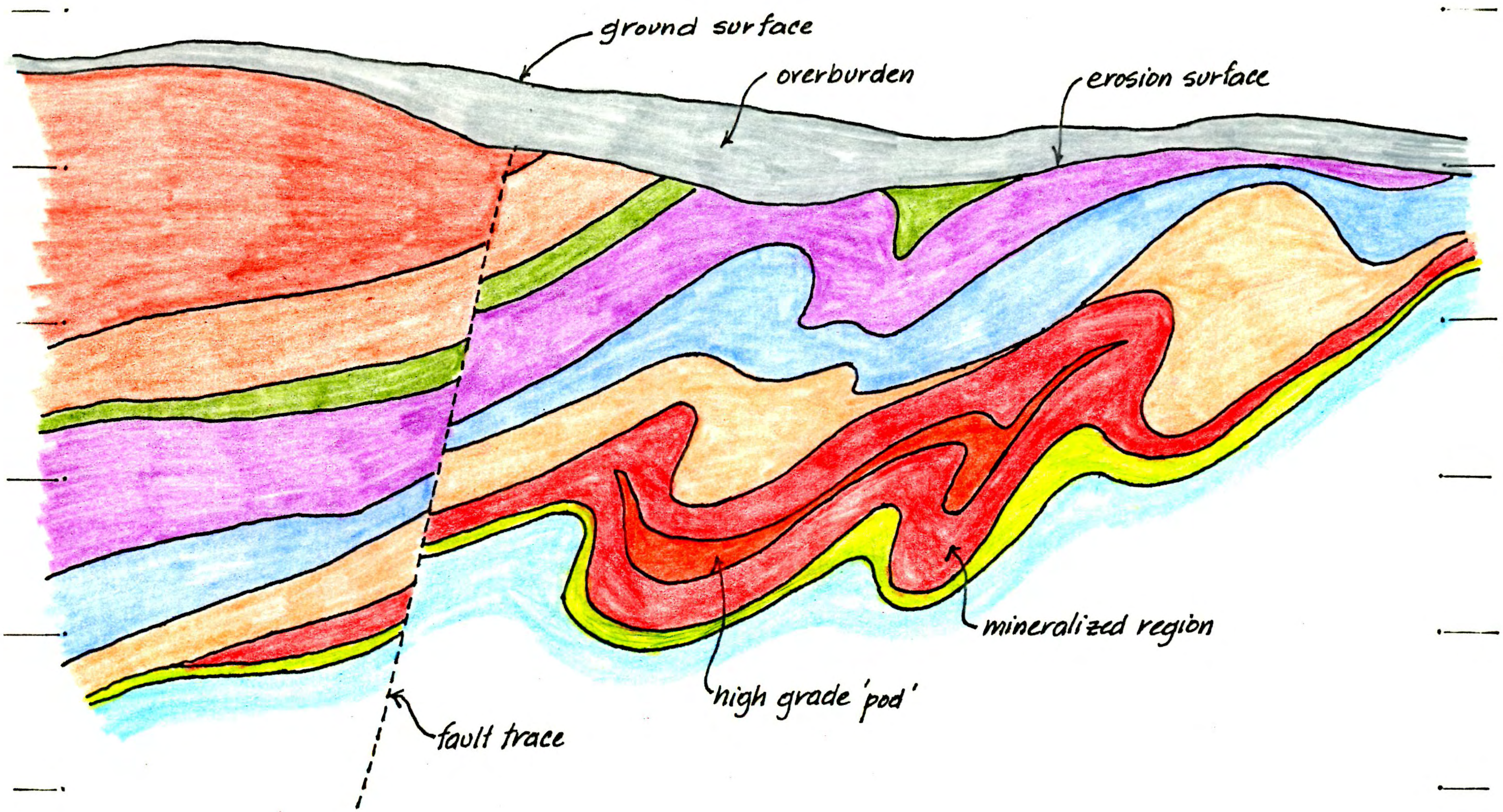

Figure 2 IDEALIZED GEOLOGICAL CROSS-SECTION

2.2 Idealization of Orebody for Mining Purposes

The orebody, as defined in the geological modelling process, is far too detailed for mine planning and operating purposes. Simplifications must be made to the geological representation to reflect:

- mining selectivity (i.e. any volume less than mining operations control limits is generally considered to be non-minable),
- host and other rock geotechnical parameters (drillability, blastability, competence, etc.),
- proposed mining methods (i.e. open-pit mining would be handled differently from underground mining),
- ore grade limits (either cut-offs or thicknesses).

These simplifications would be carried out by the project geologist in conjunction with the mine planner.

Figure 3 illustrates the results of simplifying the geological cross-section shown in Figure 2. Specific simplifications were:

- the removal of orebody segments having a thickness or width less than a critical value,
- the combination of various (unmineralized) rock types into common waste rock classes,
- smoothing of some rock type interface outlines.

Figure 3 thus presents a view of the mining reserves (as opposed to the geological reserves), the profitable extraction of which is the objective of the mine design.

All geological sections will be simplified in a similar manner. Figure 4 indicates a typical (isometric) fence diagram that could be constructed from the idealized (i.e. simplified) cross-sections. This provides a very rough and initial three-dimensional view of the mining orebody model.

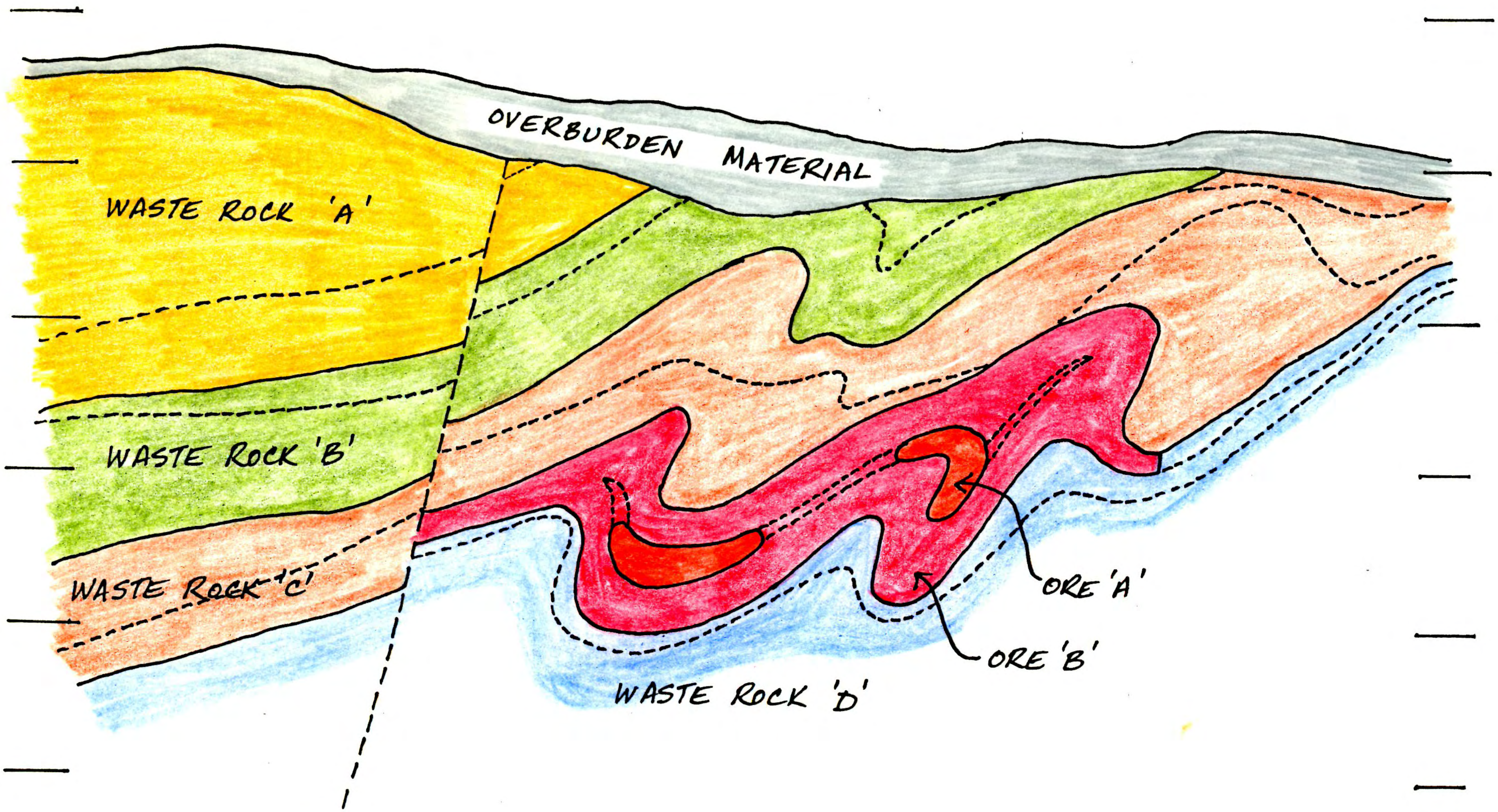

Figure 3 IDEALIZED MINING CROSS-SECTION

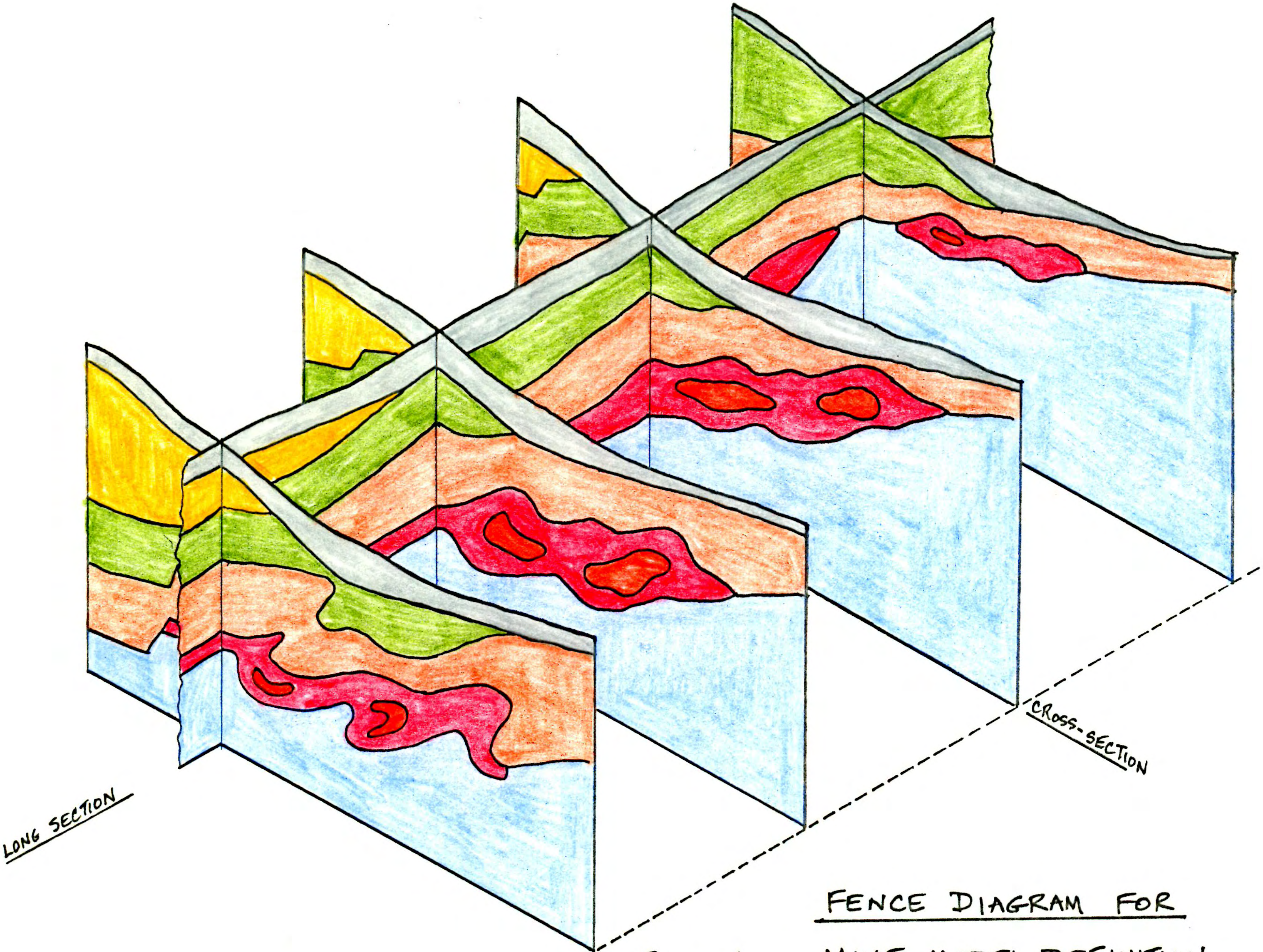

Figure 4

FENCE DIAGRAM FOR MINE MODEL DEFINITION

2.3 Material Zone Definition

After carrying out the simplification mentioned in Section 2.3, the next step is to define material zones for the cross-sections. In the Mintec MEDSYSTEM, used by Cyprus Anvil for its computerized mine design, material types are identified by unique numbers. These numbers are used on a consistent basis for each particular property and are assigned to particular material types at the time the mining project is defined. Figure 5 illustrates the numeric definition of material zones for the example mine model cross-section. Note that air is defined as a material type.

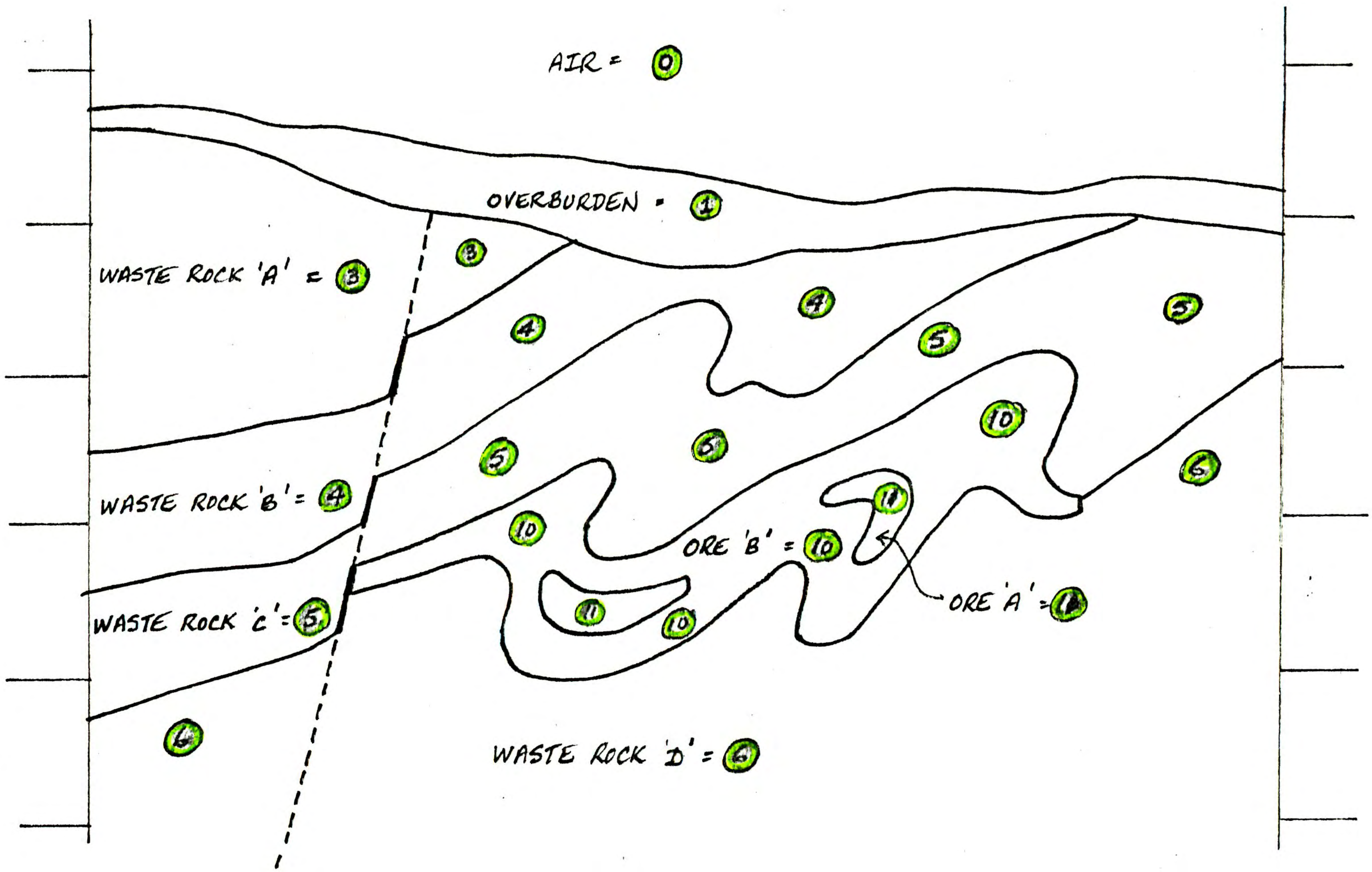

Figure 5 MINE MODEL MATERIAL ZONE DEFINITION

2.4 Cross-Section Definition and Digitizing

After defining the mine material zones, the next step is to prepare a file on the computer containing data which describes the cross-section and its material zoning. This step is the first one to actually use the computer facilities. Typically, a cross-section is defined by:

(a) its location and direction,
(b) its limits, and
(c) some geometrical description of its material regions.

This data is recorded on each cross- (or long-) section in graphical form and this must be transferred to a digital format on the computer. Defining the section location, direction and limits is straightforward but the description of material zones is much more involved. A number of methods for the definition of zones are available, ranging from bounding polygons to top surface delineation. Based on the author's experience in defining sectional material zones, a variation on the top surface delineation method has been selected for the proposed system.

The top surface delineation method for zone definition is illustrated in Figure 6. In this method, only the top surface (i.e. uppermost boundary) is specifically identified. The material type (number) below this line is included in the top surface definition and it extends downwards until another top surface line is encountered. A top surface line extends from one end point to another. Intersections of various top surface lines must also be defined, and a material zone may have a number of top surface lines. Top surface lines may also be curved as shown in Figure 6. Figure 7 indicates a condition commonly in region (zone) definition by this method. This condition occurs when a bounding line doubles back on itself. In this case, the solution is to divide the original line into single-valued segments between inflection points as shown.

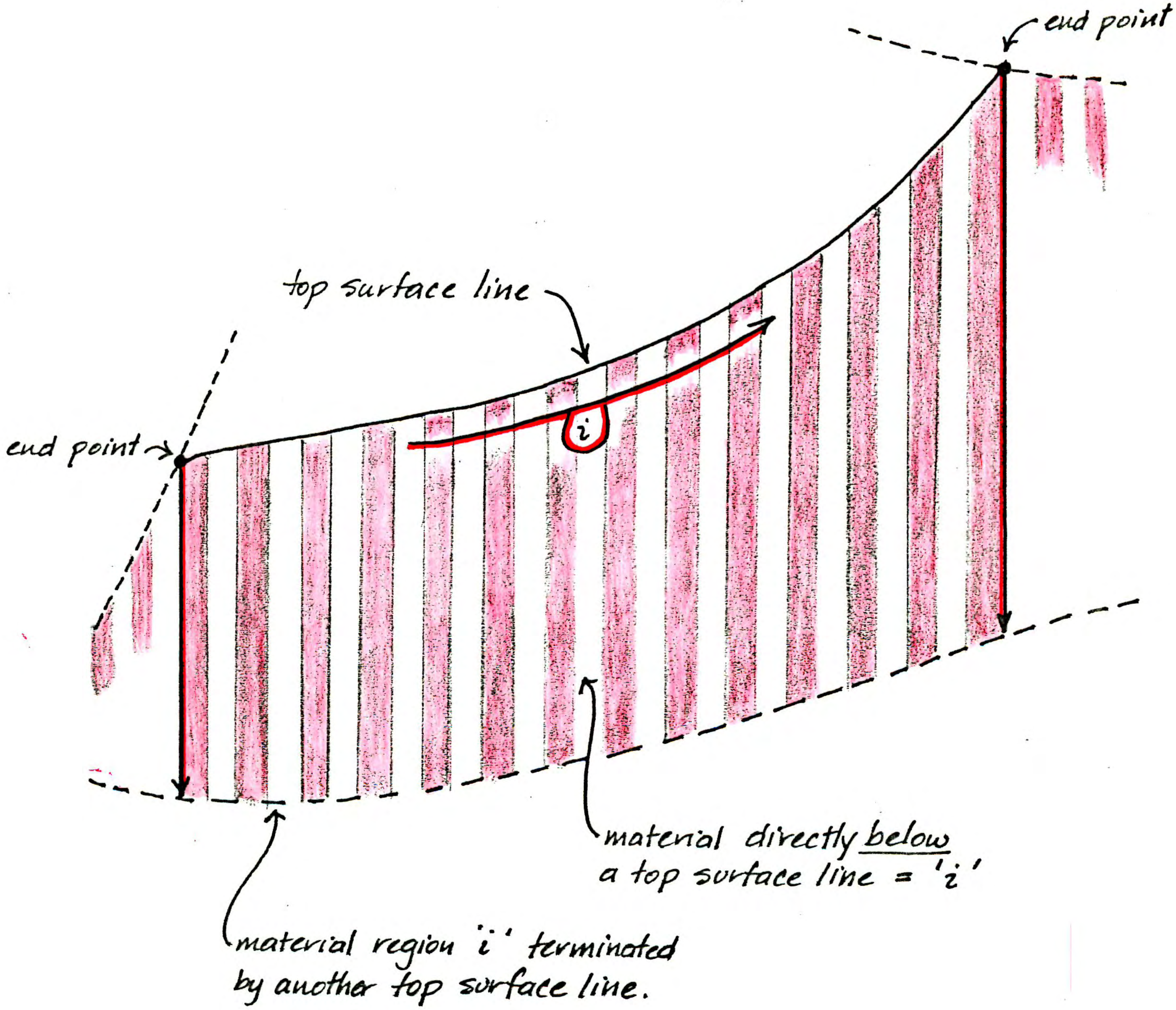

Figure 6 ZONE TOP SURFACE DELINEATION

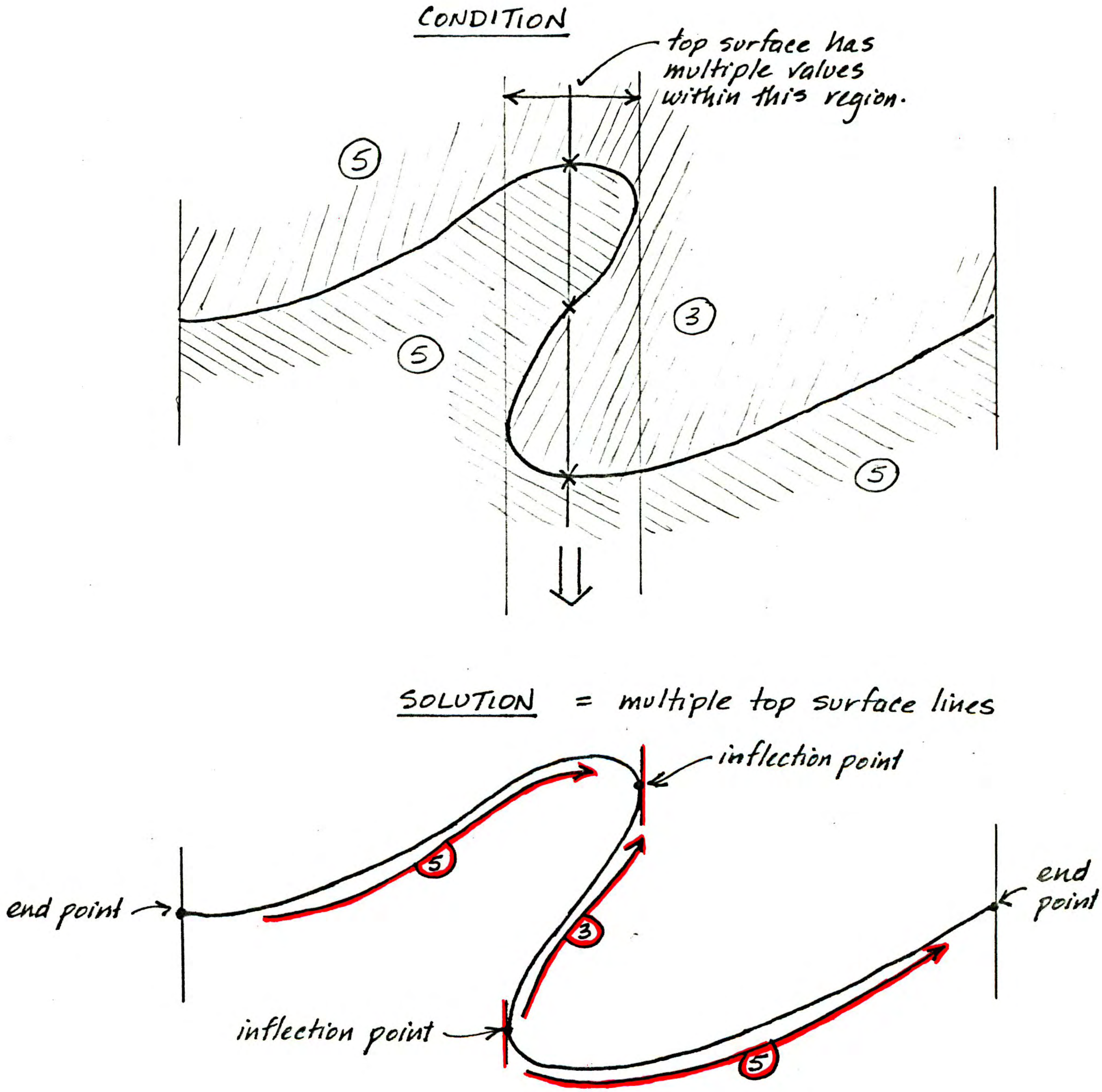

Figure 7 DEFINITION OF MULTI-VALUED TOP SURFACE LINE.

The top surface delineation method has a number of practical advantages over other zone definition methods, some of which are:

- data storage simplicity,
- need to digitize each line only once,
- ease of correction and modification.

The primary disadvantage of the method is that the geologist must closely inspect the topology of the section and identify the necessary line segments and end points.

The top surface delineation method for zone identification involves three phases of effort on the geologist's part. These phases are:

1. Identification of zone perimeter control points and line segments.

2. Digitizing of zone permimeter points.

3. Digitizing of line segments.

The first phase is illustrated in Figures 8 through 10. Material intersection points are easy to identify as they either occur at the section limits or on internal boundaries. Identification of inflection points requires close inspection of all zone boundaries and detailed geometric constructions on section drawings. The identification of zone permimeter discontinuity points serves simply to provide geological control for abrupt changes in slope of zone perimeter lines.

The next phase involves the digitizing of the identified perimeter control points. This is illustrated in Figure 11. Digitizing is the process of determining the coordinate locations of the control points in terms of the system used for the section (usually an offset from a centre line and an elevation). Digitizing may be done using manual measurements but is more effectively done on an electronic digitizing table.

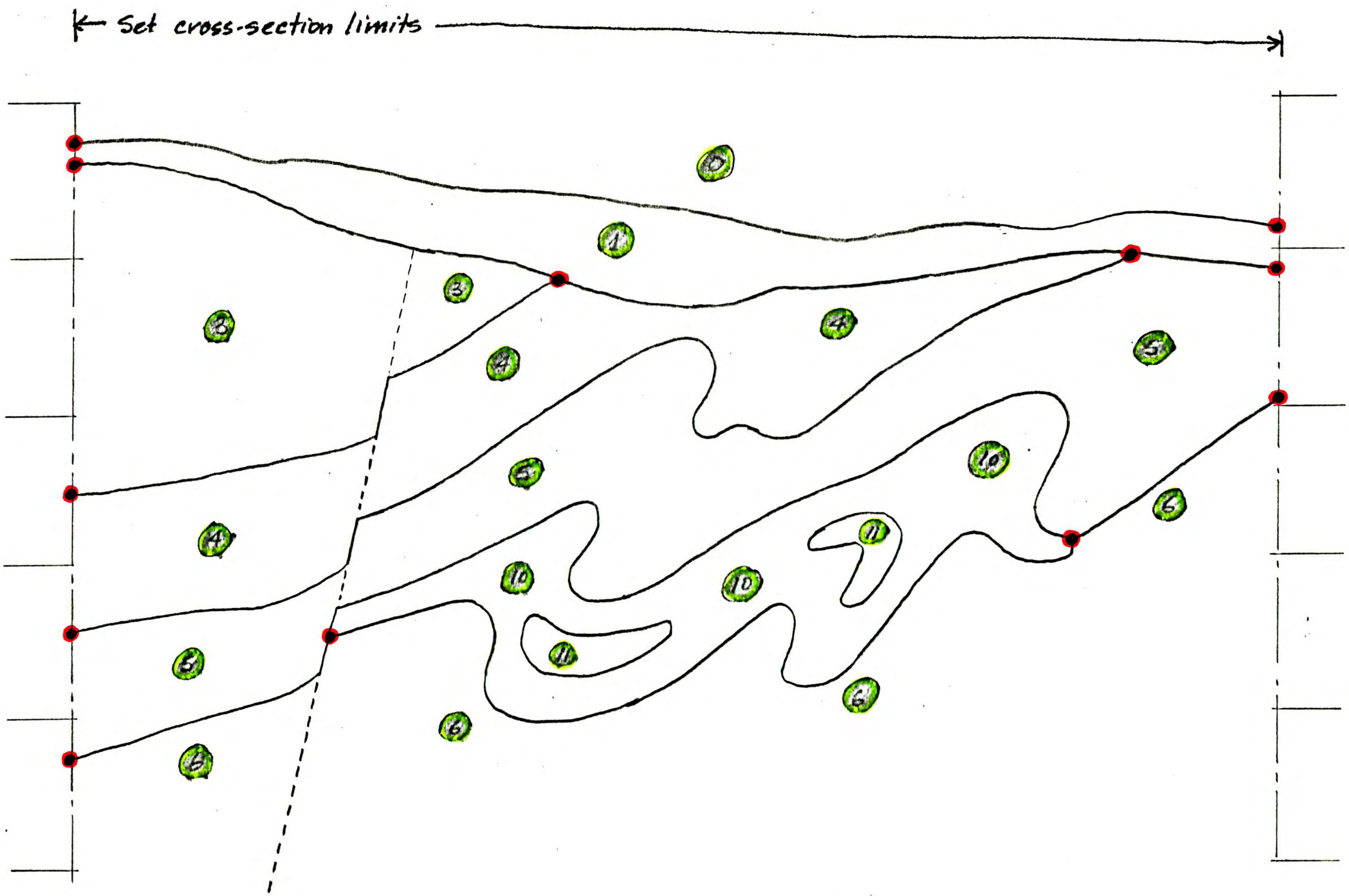

Figure 8 IDENTIFY - MATERIAL INTERSECTION POINTS

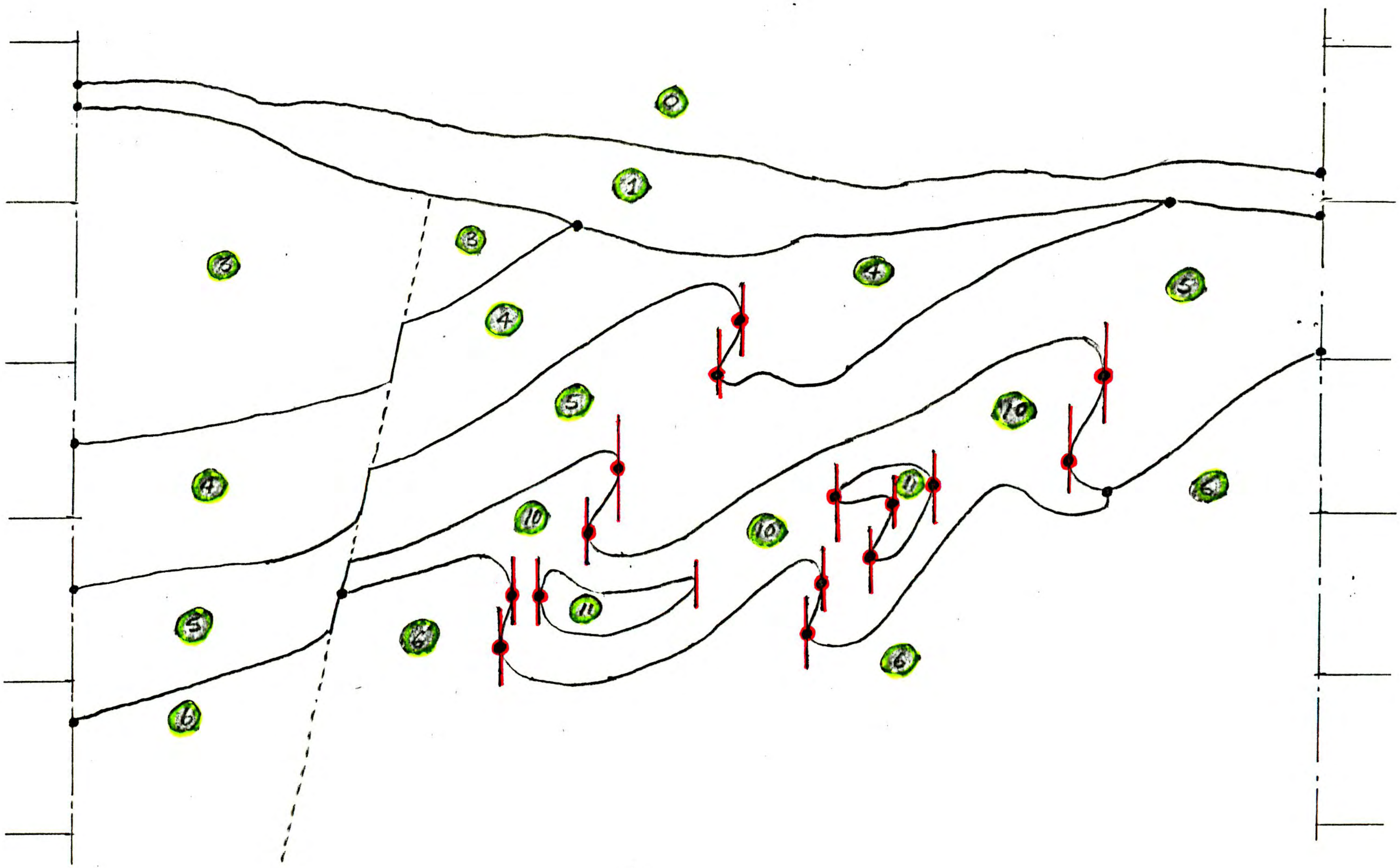

Figure 9 IDENTIFY - ZONE PERIMETER INFLECTION POINTS.

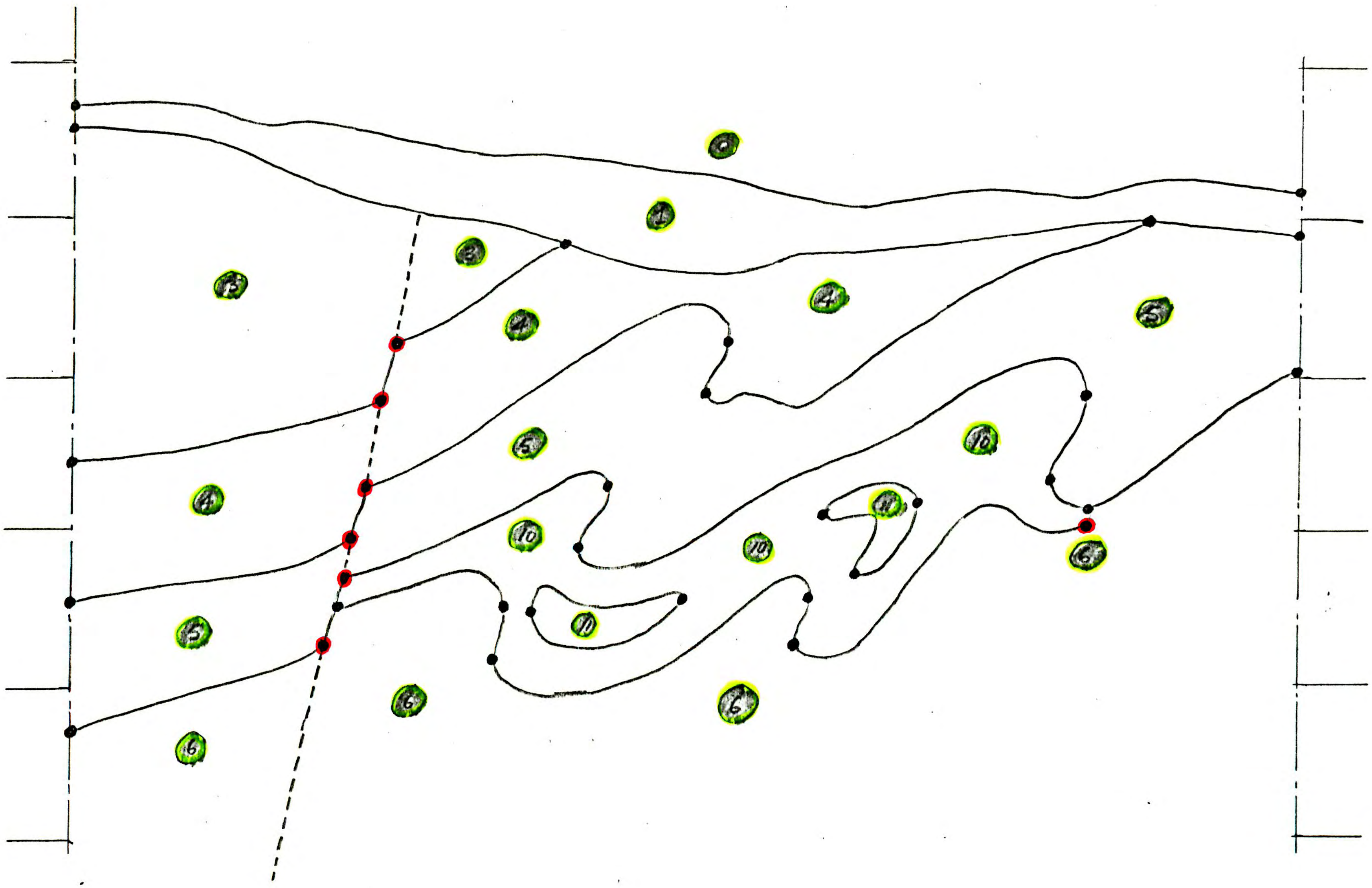

Figure 10 IDENTIFY - ZONE PERIMETER DISCONTINUITY POINTS

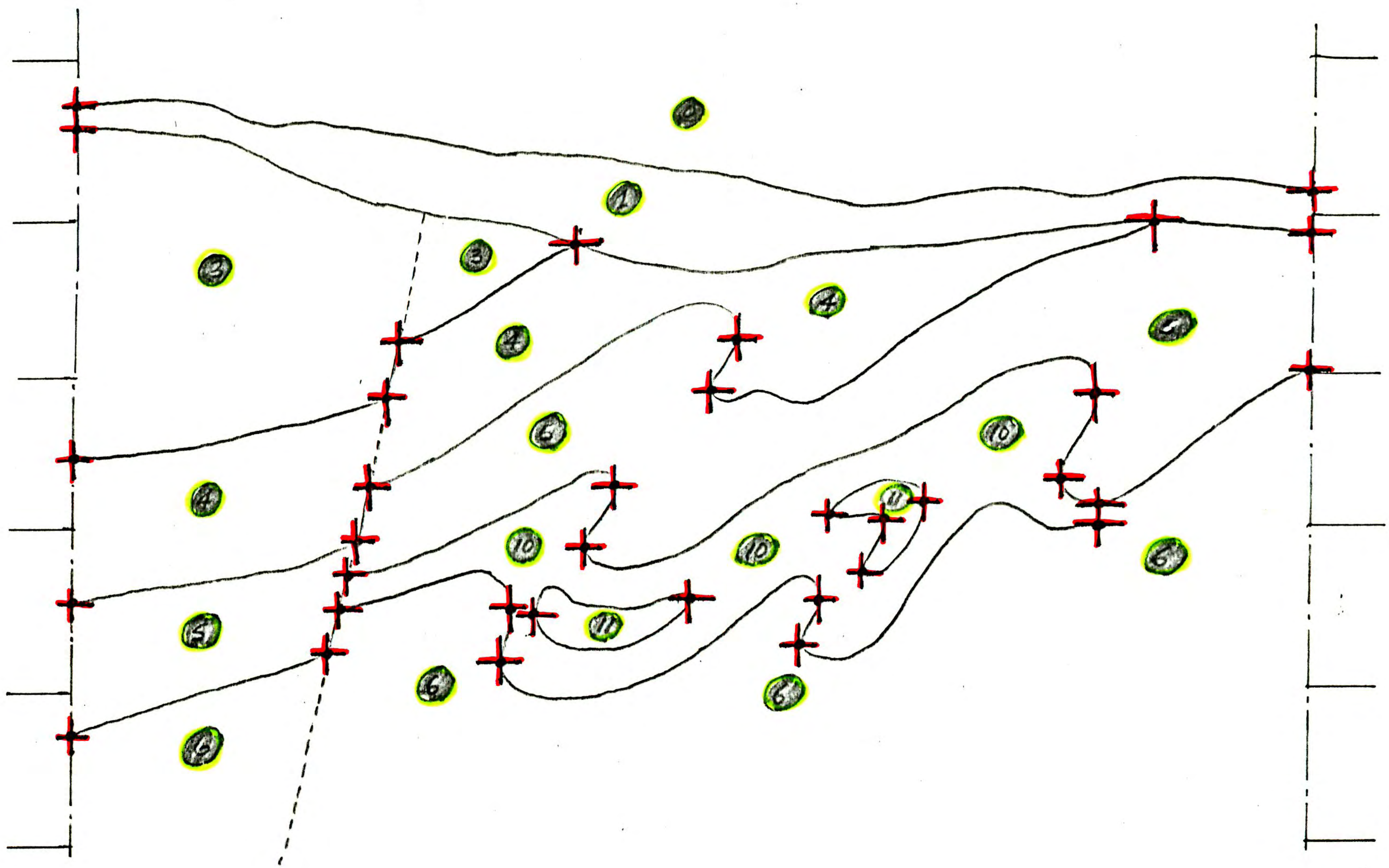

Figure 11 DIGITIZE - ZONE PERIMETER POINTS

The third and final phase is the digitizing of the line segments making up the top surface definition lines. The method is illustrated by Figure 12. The line segments are approximated by a series of digitized points located at invervals between the end points. The actual top surface line is then composed of many small straight lines joined at the digitized points. On the scale used for geological cross-sections, this simplification does not cause any significant error.

All top line segments are digitized using the method and are assigned, at this time, with the material number of the region directly below the line. This operation for the example section is illustrated by Figure 13. (The top surface for air does not have to be digitized as the method presumes that the section is all air until the top surface lines for all the material zones are input.)

The above phases would be repeated for each cross- and long-section defined for the property. The digitized data for all sections would then be collected and merged together to form a 'Property section data file'. This data file would be saved as a permanent file for use in subsequent data processing activities.

(The actual computing process involved in the above phases has not as yet been detailed. It will be a recursive process, however, in that each data input phase will have to be checked for errors and accuracy and, if necessary, portions of it will have to be redone.)

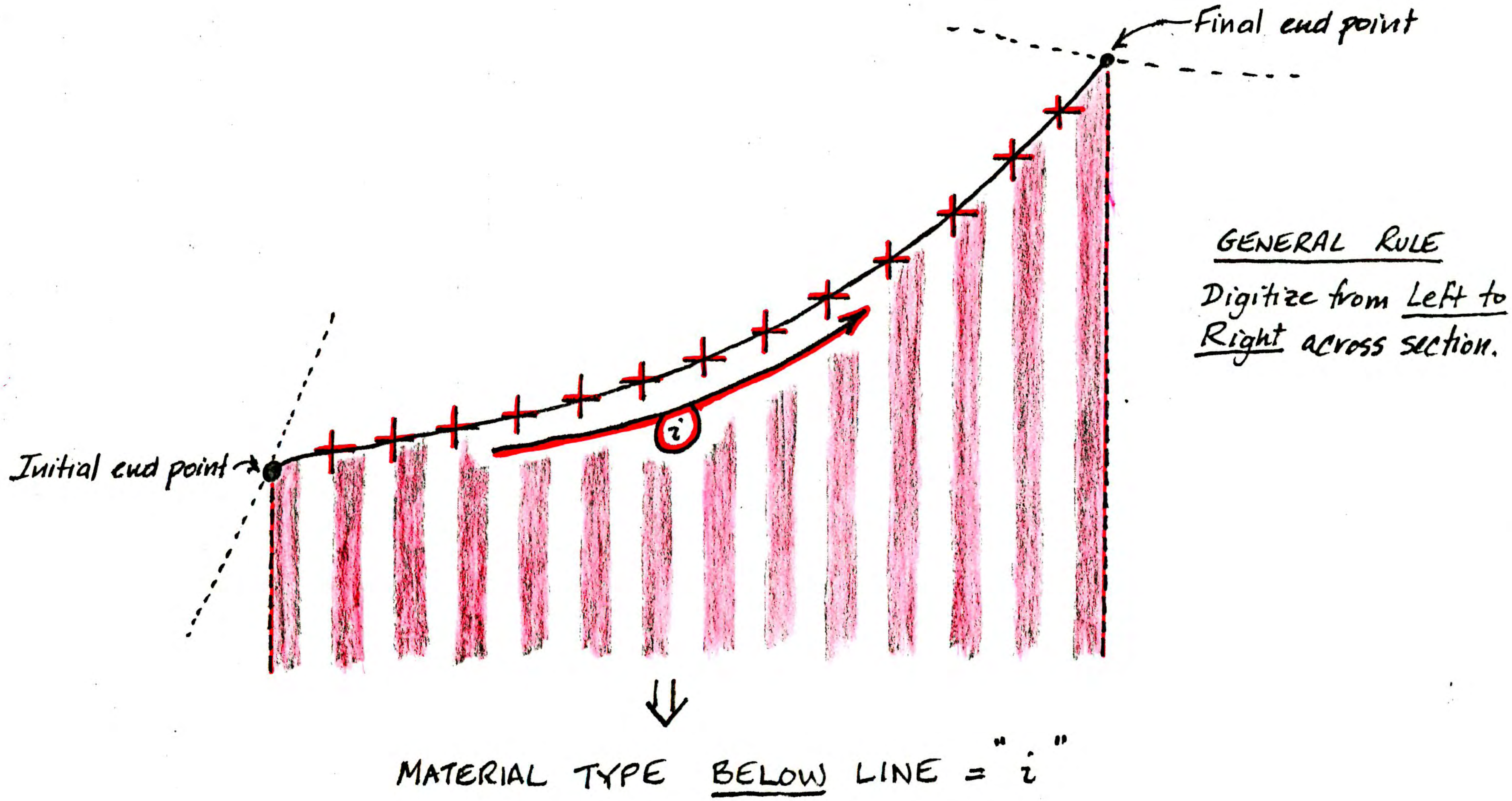

Figure 12 ZONE TOP SURFACE DIGITIZING

Figure 13 DIGITIZE - ZONE PERIMETER LINE SEGMENTS

2.5 Bench Material Zone Intersections

After a 'Property section data file' has been created, the mining engineer will specify the bench elevations for an open-pit mine (or levels for an underground mine). The next program segment in the proposed system will calculate intersections of mid-bench lines with material zones (as illustrated in Figure 14) on all stored sections and will plot the horizontal (i.e. plan) locations of such points. Figure 15 illustrates the bench/material zone intersection calculation process for one bench through our example section. This program will also determine the material type extant between the calculated intersection points.

Figures 16 and 17 are illustrations of the same bench/material zone intersection plot with separate annotations explaining intersections on cross- and long-sections. Should different bench (or level) sequences require evaluation, this stage would be re-run as necessary.

Bench/material zone intersection plots would be produced for every defined bench in a specific mine model.

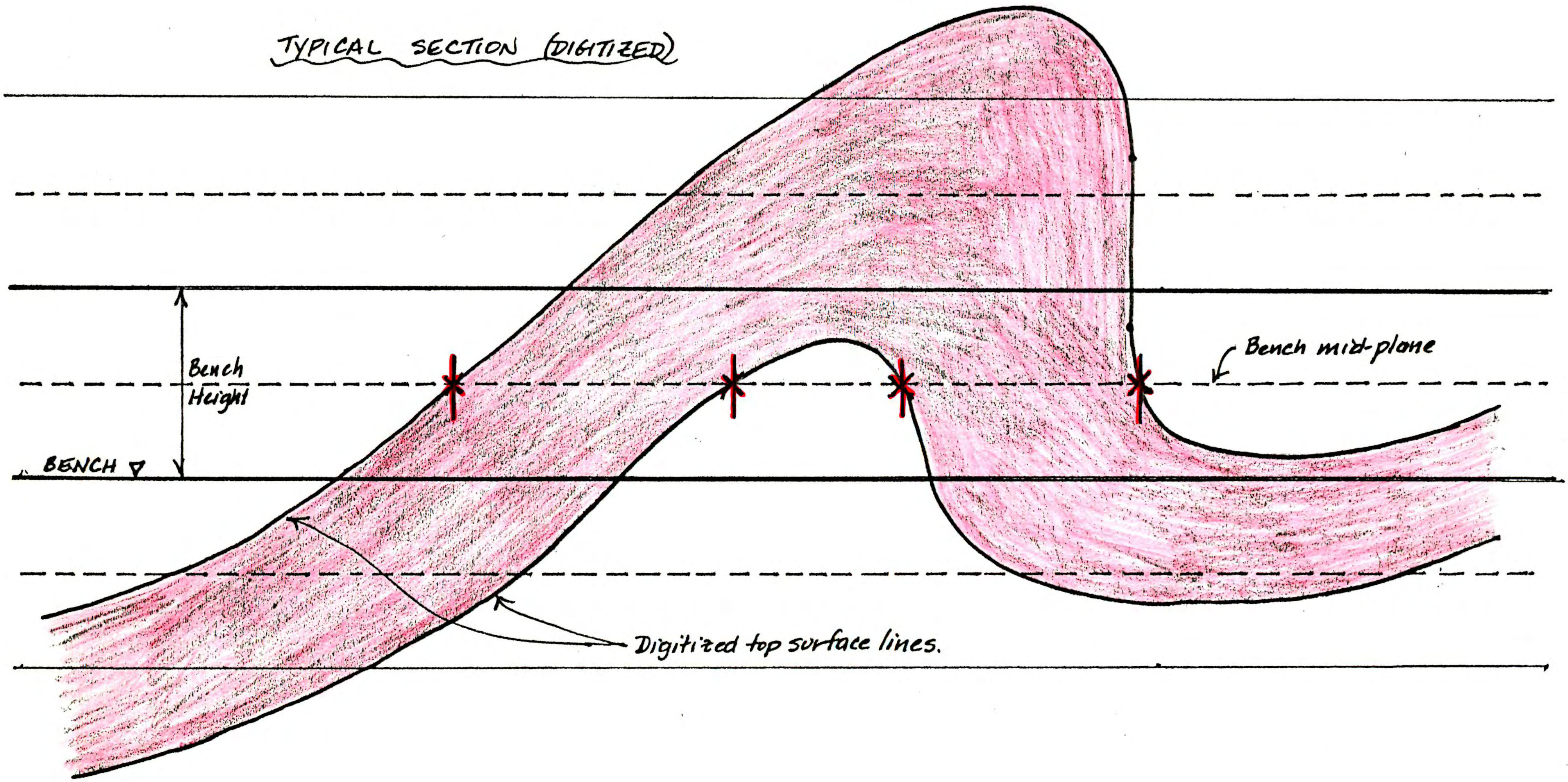

Figure 14 MID-BENCH / ZONE INTERSECTION POINTS

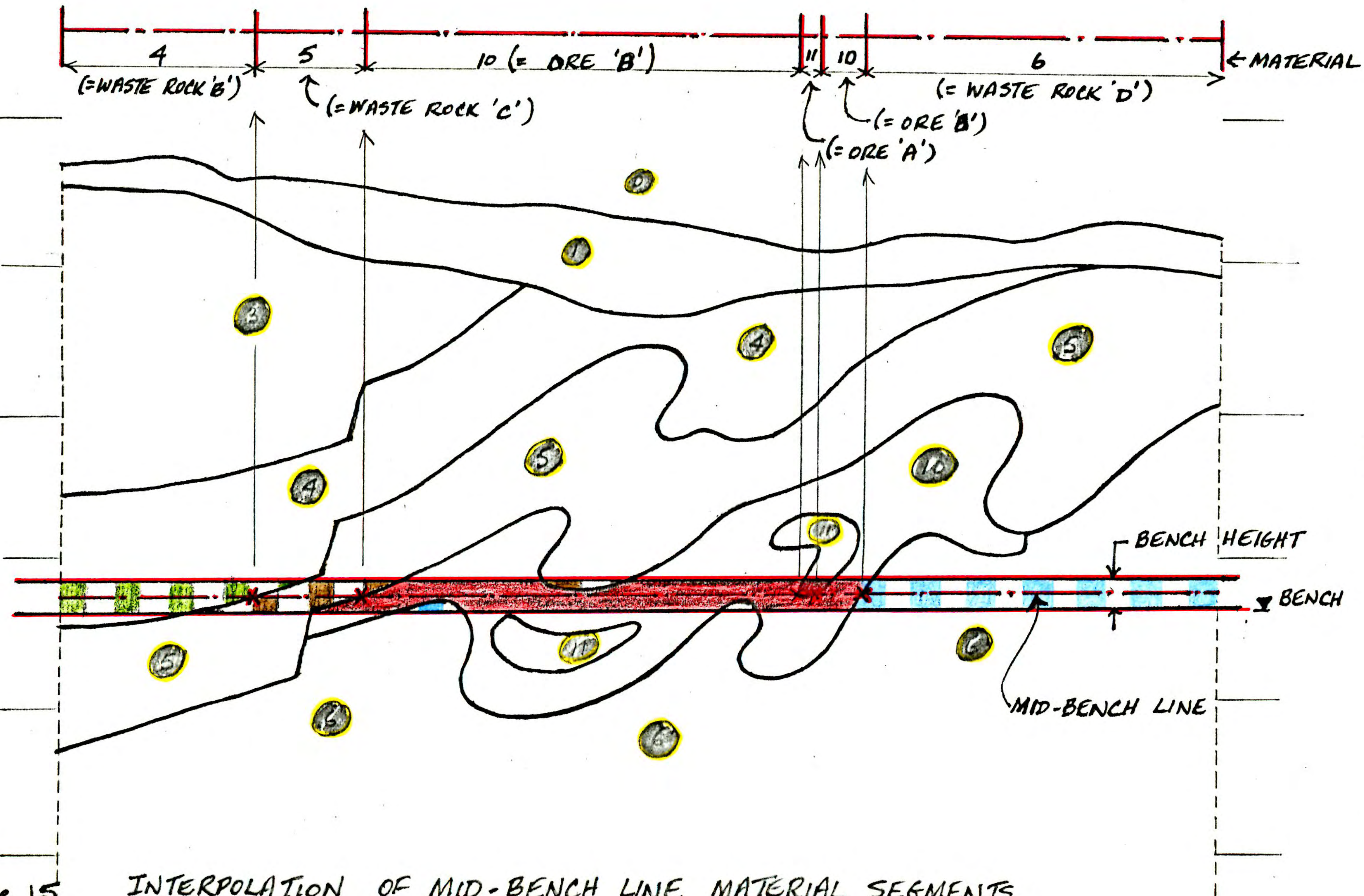

Figure 15 INTERPOLATION OF MID-BENCH LINE MATERIAL SEGMENTS

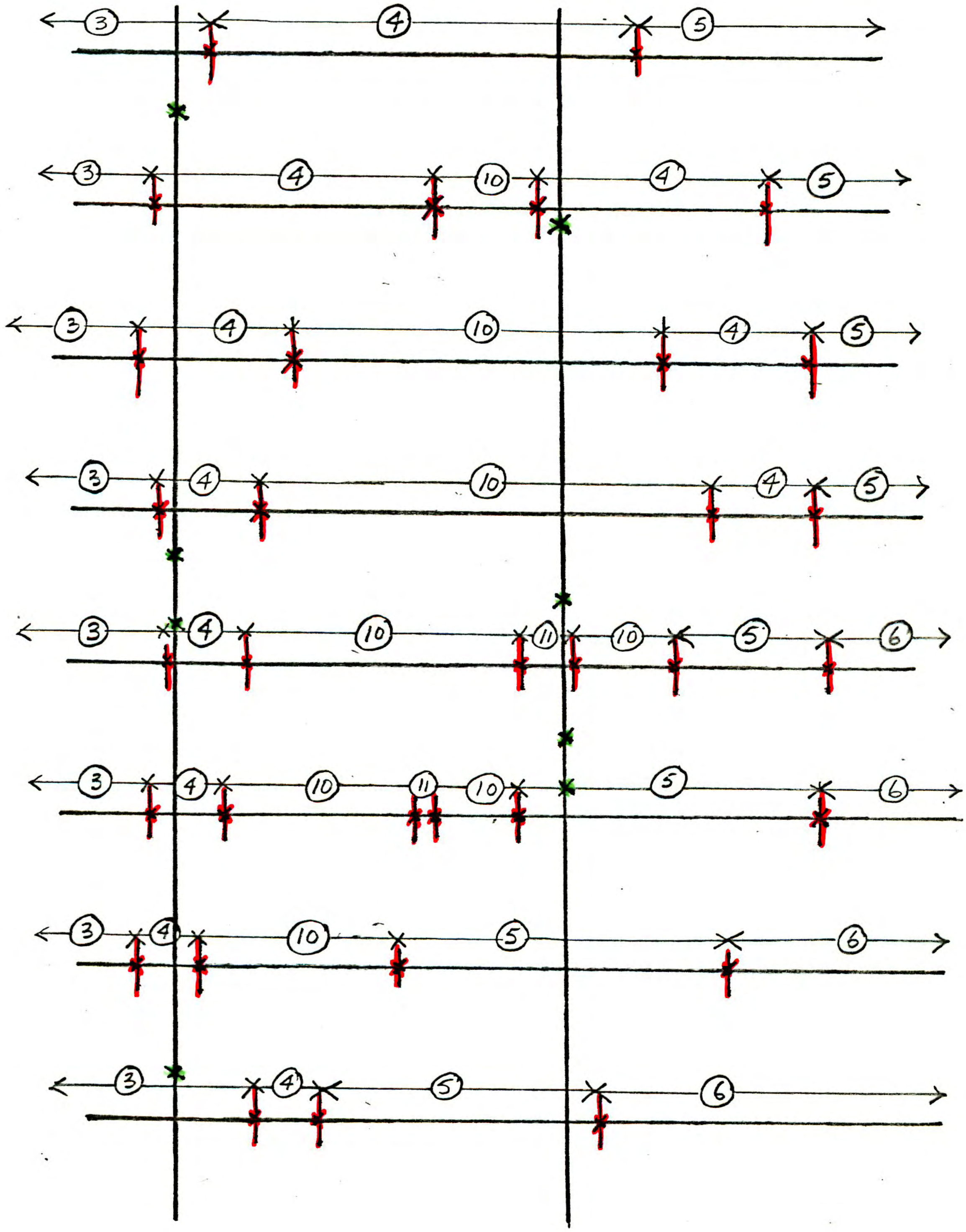

Figure 16 INTERPOLATED MATERIAL SEGMENTS FOR CROSS-SECTIONS ON A SPECIFIC MID-BENCH PLANE

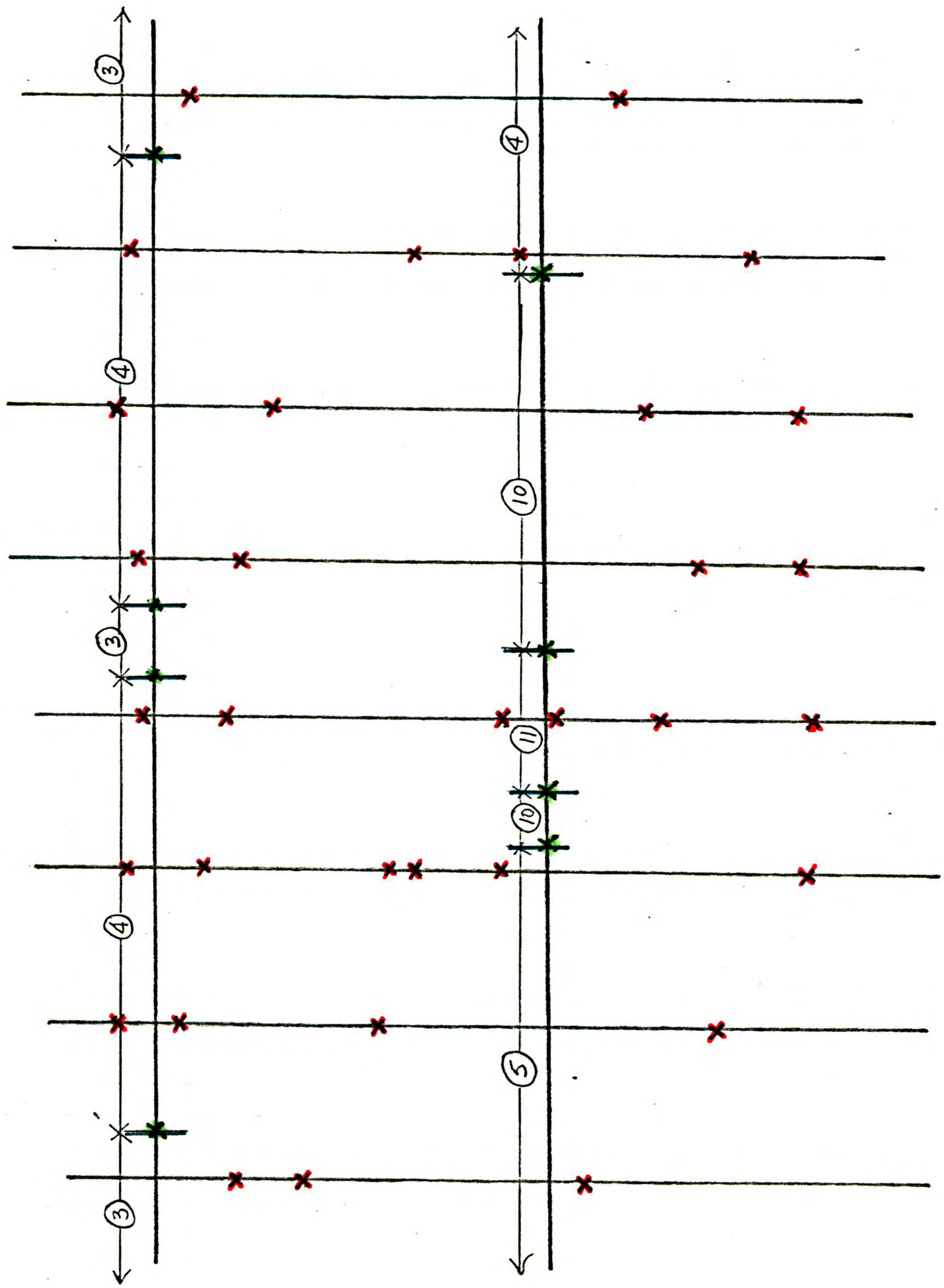

Figure 17 INTERPOLATED MATERIAL SEGMENTS FOR LONG-SECTIONS ON A SPECIFIC MID-BENCH PLANE

2.6 Bench Material Zone Definition

Once bench/material intersection plots have been produced by the system, the next step is for the project geologist to prepare bench material zone plans. Figure 18 is the result of a geological interpretation of the bench/material intersection plot of Figure 16 (and Figure 17). Thus the system has been used up to this point solely to produce accurate points on bench plans. Control is now returned to the geologist who is responsible for the final geological input to the mine model. He may elect to use the calculated intersection points in the bench plan or may replace (shift) them as it suits his own particular understanding of the geological nature of the property.

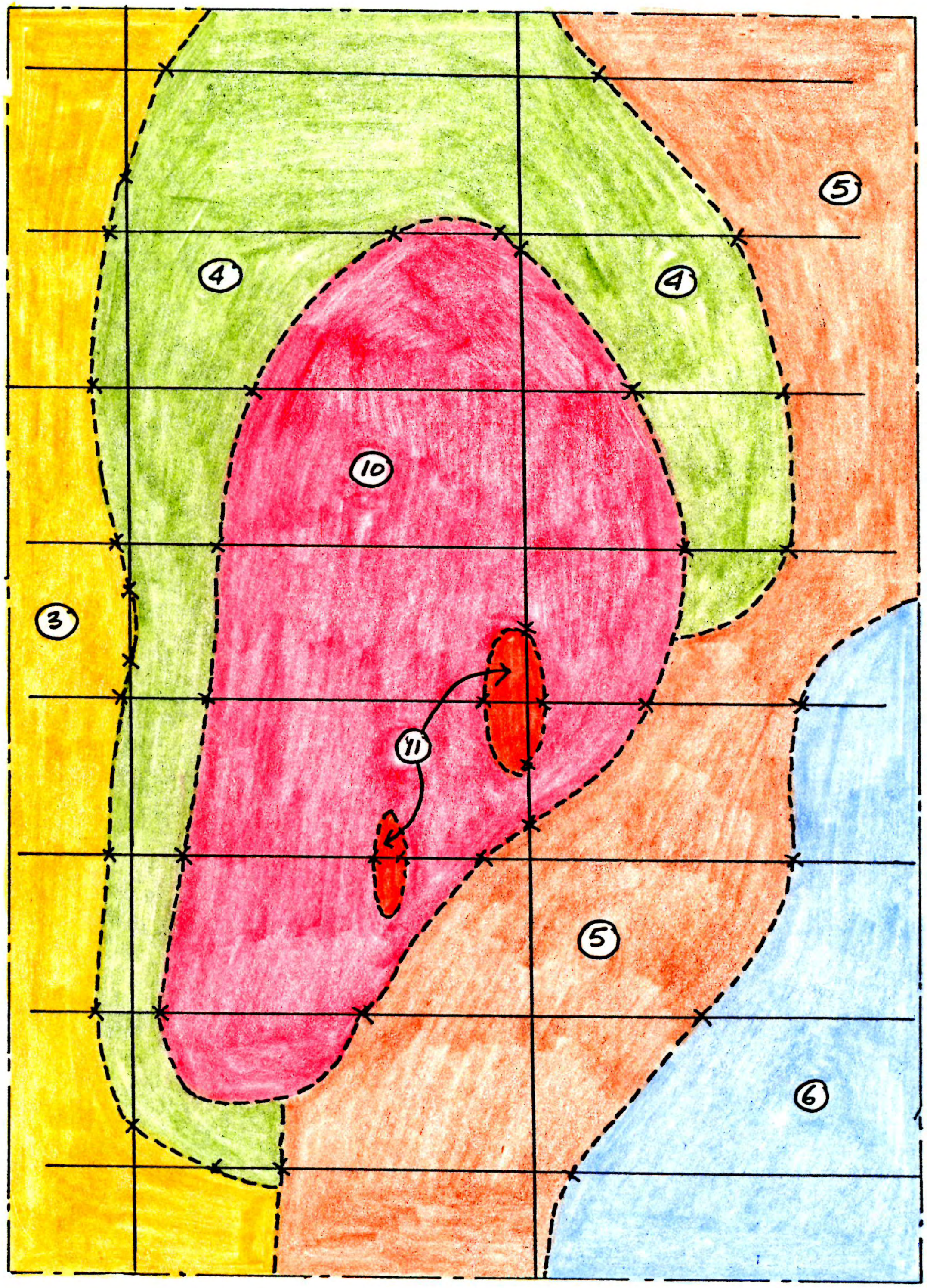

Figure 18 BENCH MATERIAL ZONE DEFINITION

(Interpreted by geologist(s) from interpolated material segments on long and cross-sections)

2.7 Bench Plan Identification and Digitizing

After the geologist defines the bench plan material zones, the next step will be to prepare a file on the computer containing data which describes the bench plan and its material zoning. Typically, a bench plan will be identified by:

(a) its elevation,
(b) its lateral extent, orientation and coordinates,
(c) its height, and
(d) some geometrical description of its material regions.

As shown in Section 2.6, this data has been recorded on a plan in graphical form which must be transferred to a digital format on the computer. As for the cross- and long-sections (Section 2.4), this is a straightforward process except for the description of the material regions. Again, a variation on the top surface delineation method has been chosen for bench material region definition.

Initially, a series of bounding lines is set out for the benches. (This should be consistent for all benches in a property.) This would be oriented with respect to the overall N,E coordinate system (Figure 19). In this case, the 'up' direction is now presumed to be coincident with the North coordinate direction. The bench plan would then be defined and digitized in a manner similar to that used for the cross- and long-sections. The top surface delineation method would involve the standard three phases of effort on the geologist's part, viz:

1. Identification of bench zone perimeter control points and line segments (Figures 20 and 21).

2. Digitizing of bench zone perimeter points (Figure 22).

3. Digitizing of bench material zone line segments (Figure 23).

The same rules and algorithms would be followed as for the sections, and the process would be repeated for all benches in the property.

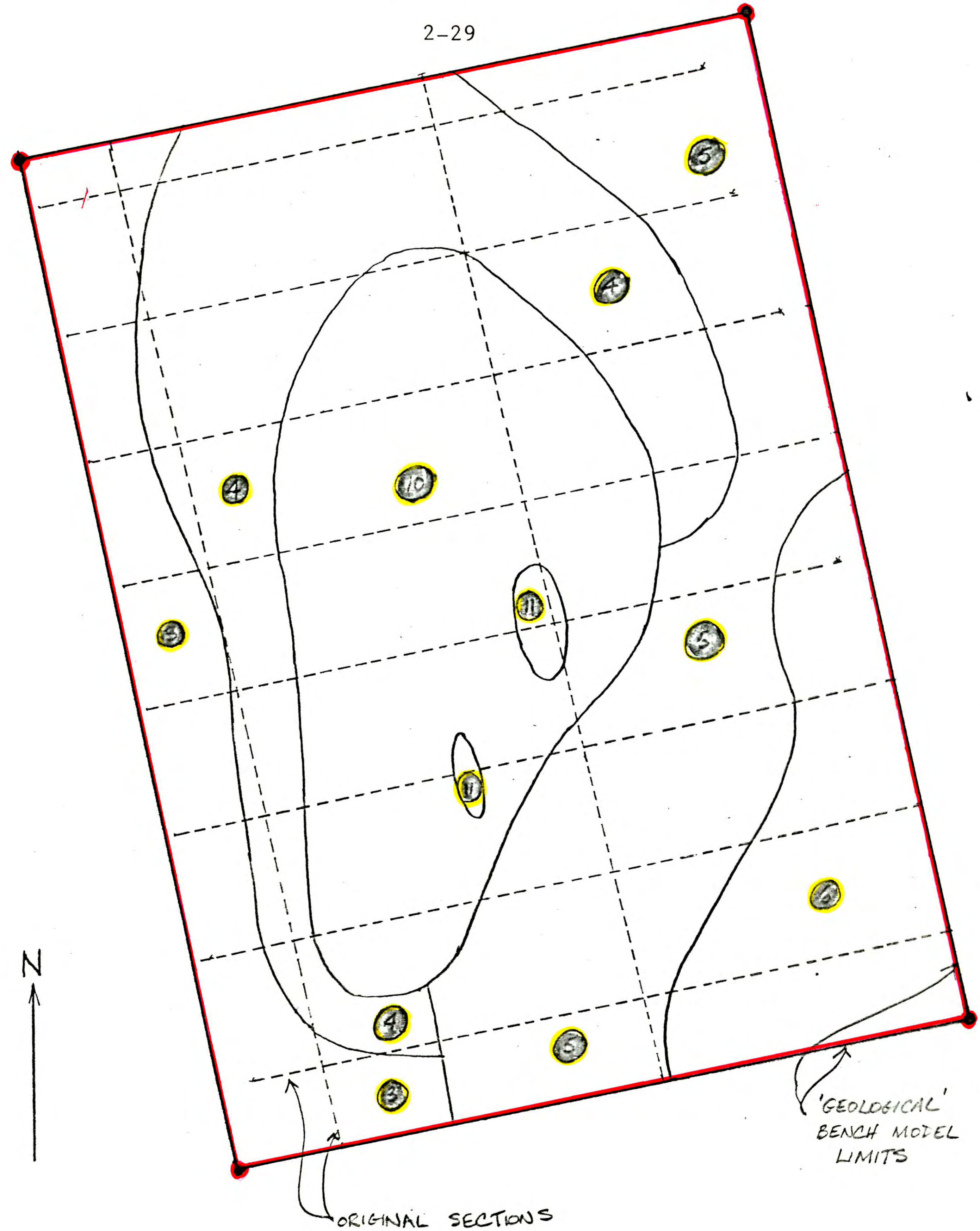

Figure 19 SET BENCH DEFINITION (MODEL) LIMITS

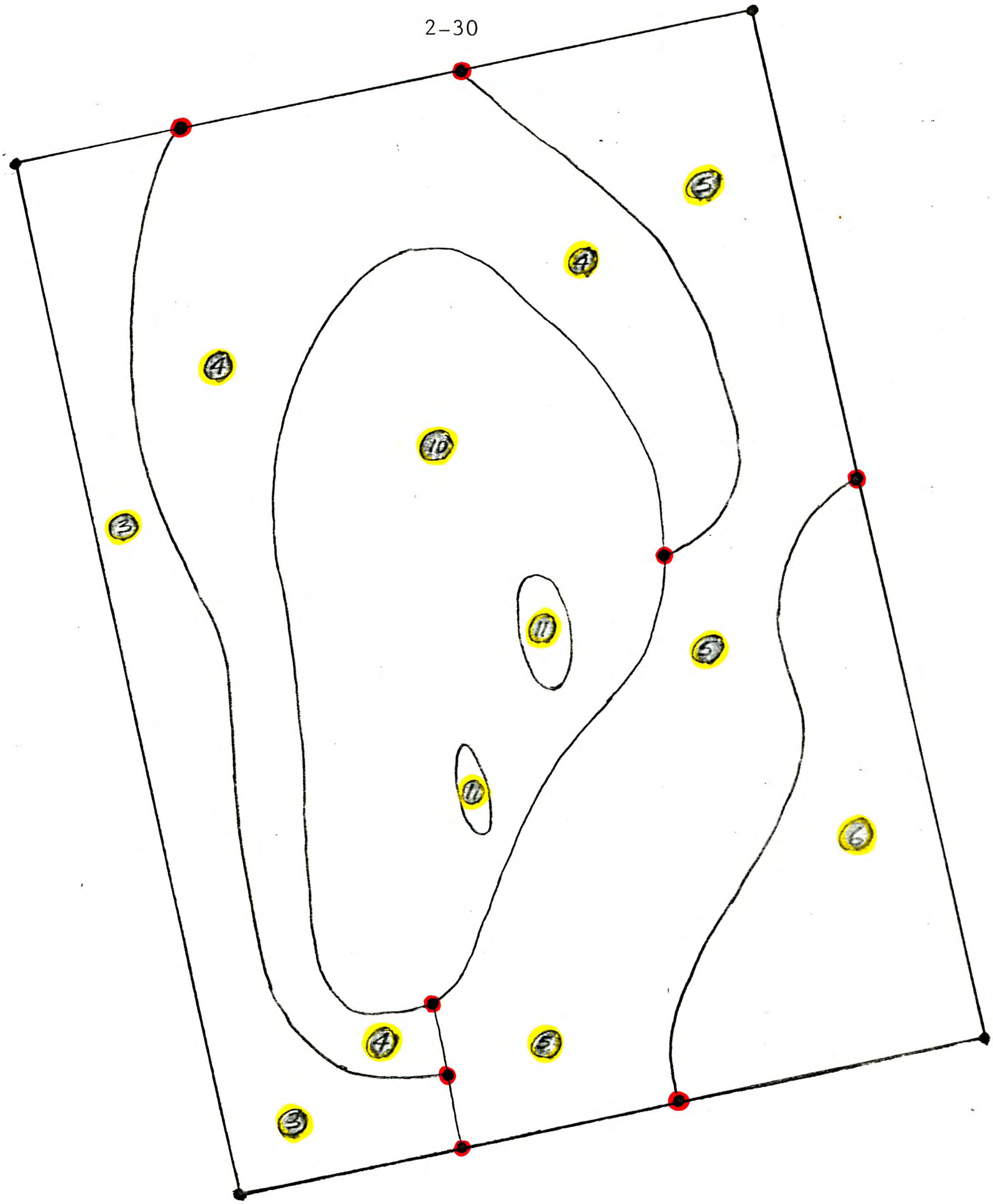

Figure 20 IDENTIFY - BENCH ZONE INTERSECTION POINTS

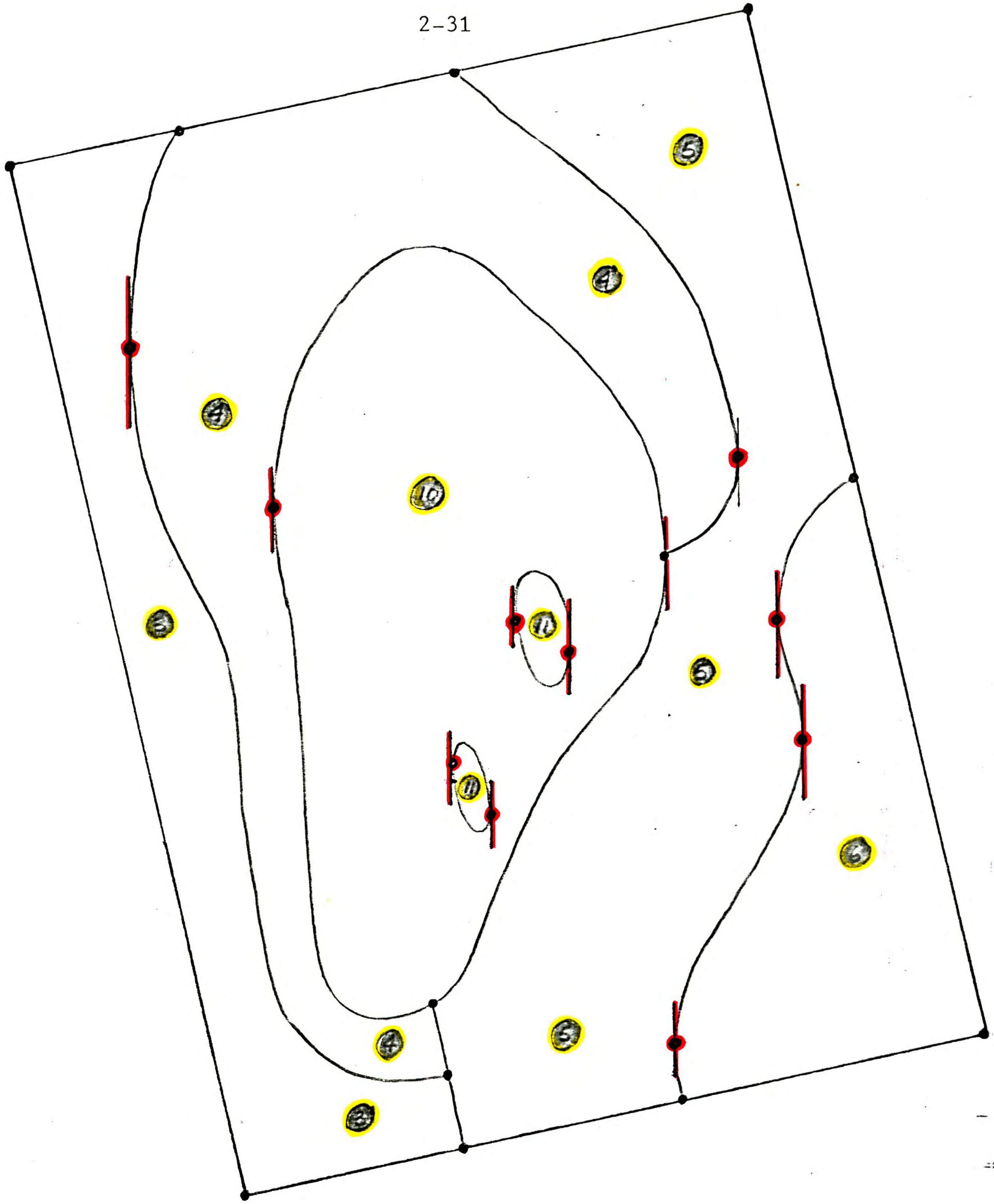

Figure 21 IDENTIFY - BENCH ZONE INFLECTION POINTS

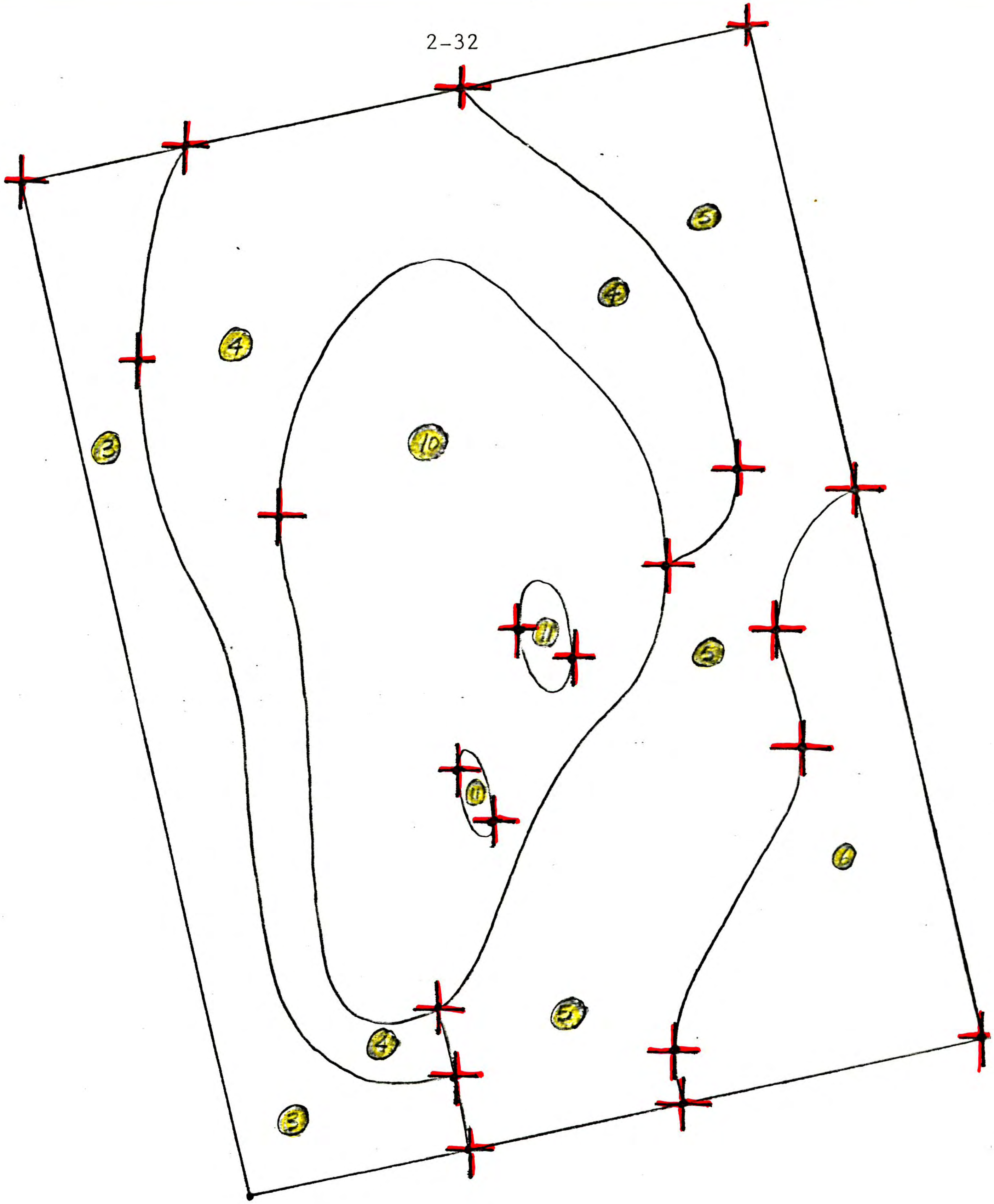

Figure 22 DIGITIZE - BENCH MATERIAL ZONE POINTS

Figure 23 DIGITIZE - BENCH MATERIAL ZONE LINE SEGMENTS

2.8 Generation of Bench Block Material Codes

After the bench material zones have been digitized and checked, the resulting data file is merged with those for the other benches to form a common mine bench model file. The project mining engineer will usually, by this time, have decided on mine block model spacing and orientation and the next step of the mine block model parameter generation process is initiated. This consists of a specification of the mine block model origin (N, E, El.) coordinates, orientation angle, to a separate program which interpolates the material zones for each bench and assigns appropriate material codes to the blocks. Figure 25 illustrates the process as carried out for our example bench.

There will probably be a number of decision algorithms required at this stage, as well as block material type modification facilities for final direct geological control. One of the primary forms of output will be a plot of bench block material types to permit ready checking by the project geologist and mining engineer.

Ancillary programs will also have to be available at this stage to convert the block model data into a format suitable for use by the Mintec MEDSYSTEM on the CSC system in Calgary.

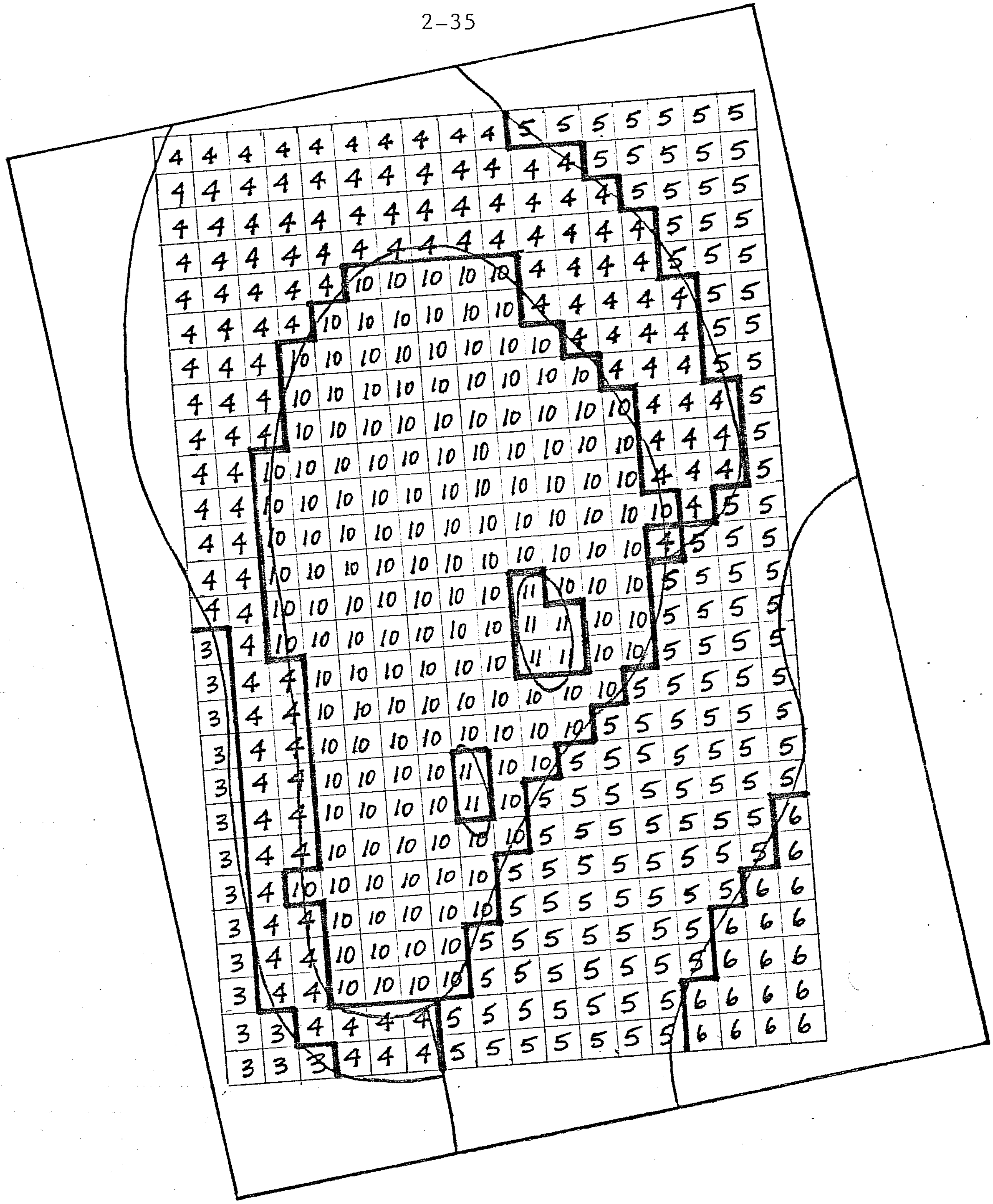

Figure 24 INTERPOLATION OF BENCH BLOCK MATERIAL CODES

3.0 OVERVIEW OF PROPOSED SYSTEM

The functional capabilities of the proposed system for generation of mine block model parameters from geological sections are presented in the previous section of this report. This section will describe the various computer program components and data file structures involved in the proposed system. The associated computer hardware and operating system software needed will also be outlined. The reader should note that, although the list of resources required is extensive, the majority of the hardware and operating system software components is currently installed in Faro and Vancouver. Those components not installed would normally have many other uses by Cyprus Anvil and thus need not be purchased specifically for the proposed system. Likewise, many of the applications software components needed would be used for other related purposes by Cyprus Anvil.

3.1 System Structure

The proposed system for generation of mine block model parameters from geological sections would involve the development of a set of modular computer programs with some form of centralized data management. The general data processing flow for the system is illustrated in moderate detail in Figure 25. Each rectangular box in this figure represents a component program to be developed. The main data storage facility for the system is currently considered to be a suitable data base application (illustrated in Figure 26). It is not possible, at this time, to be more specific about the component programs and data storage facility as the author's current knowledge of HP-3000 computer system capabilities and restrictions is rather limited. The level of detail presented, though, is sufficient for discussion within Cyprus Anvil.

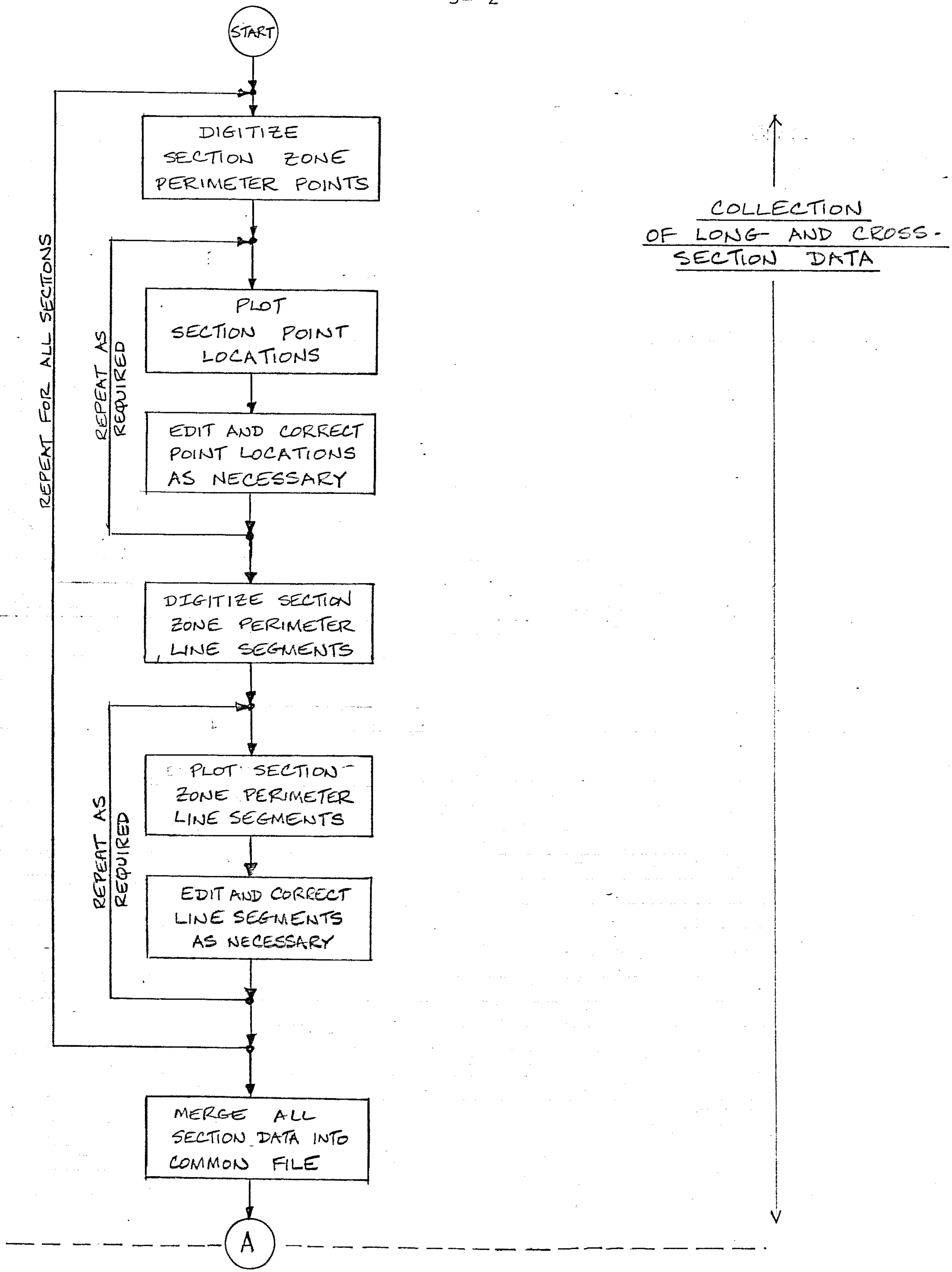

Figure 25 PROPOSED SYSTEM FLOWCHART

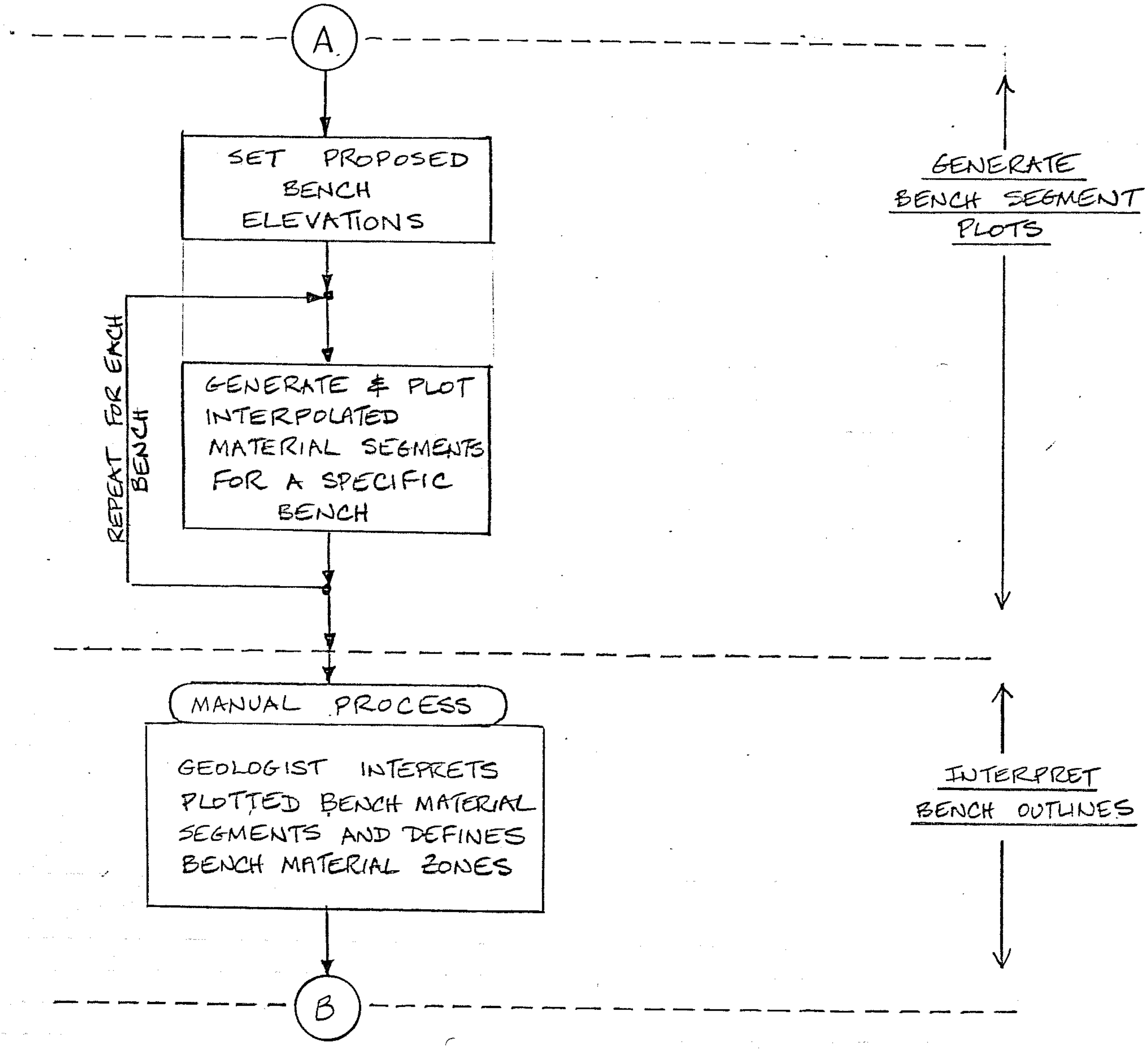

Figure 25 PROPOSED SYSTEM FLOWCHART (Continued)

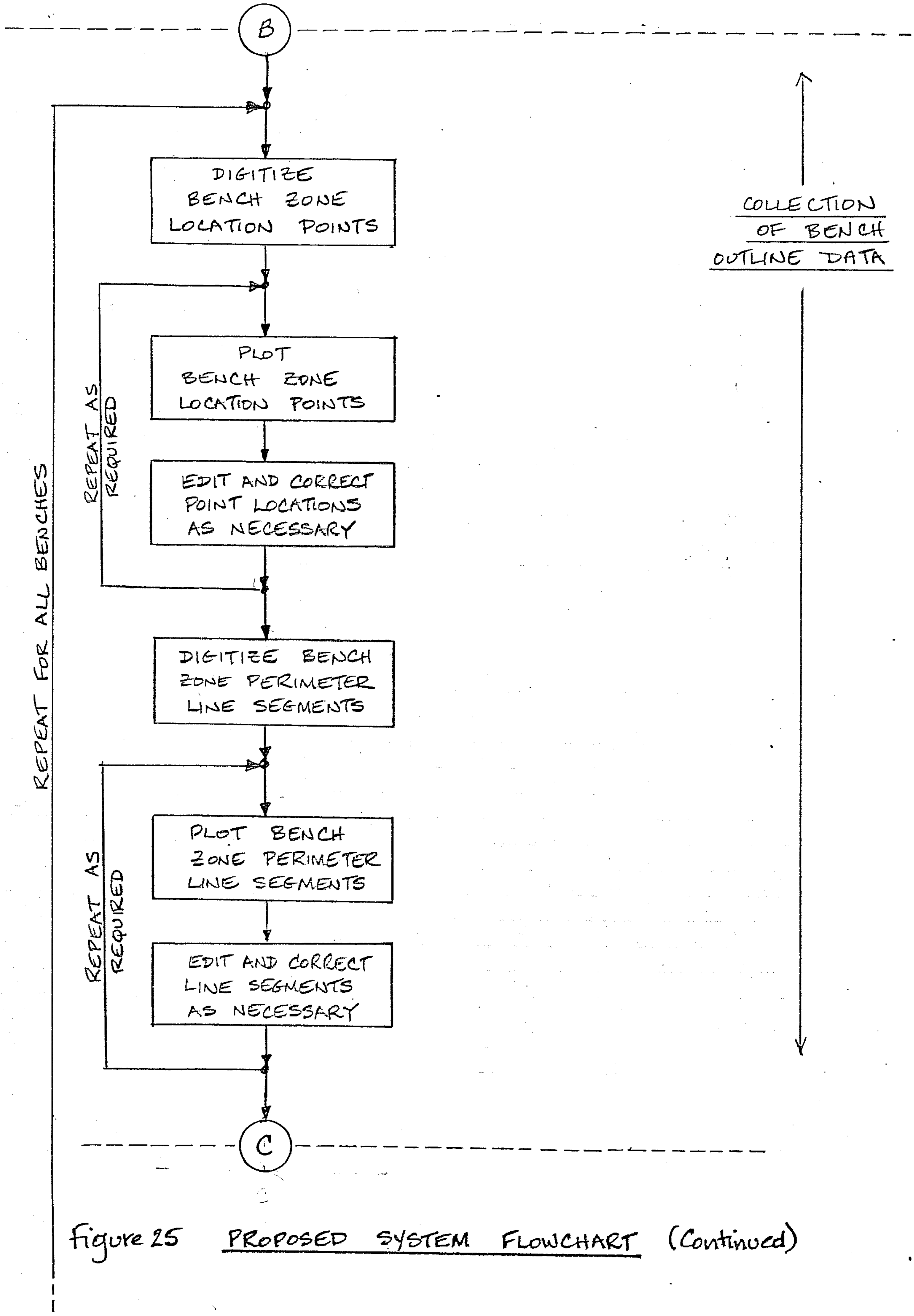

Figure 25 PROPOSED SYSTEM FLOWCHART (Continued)

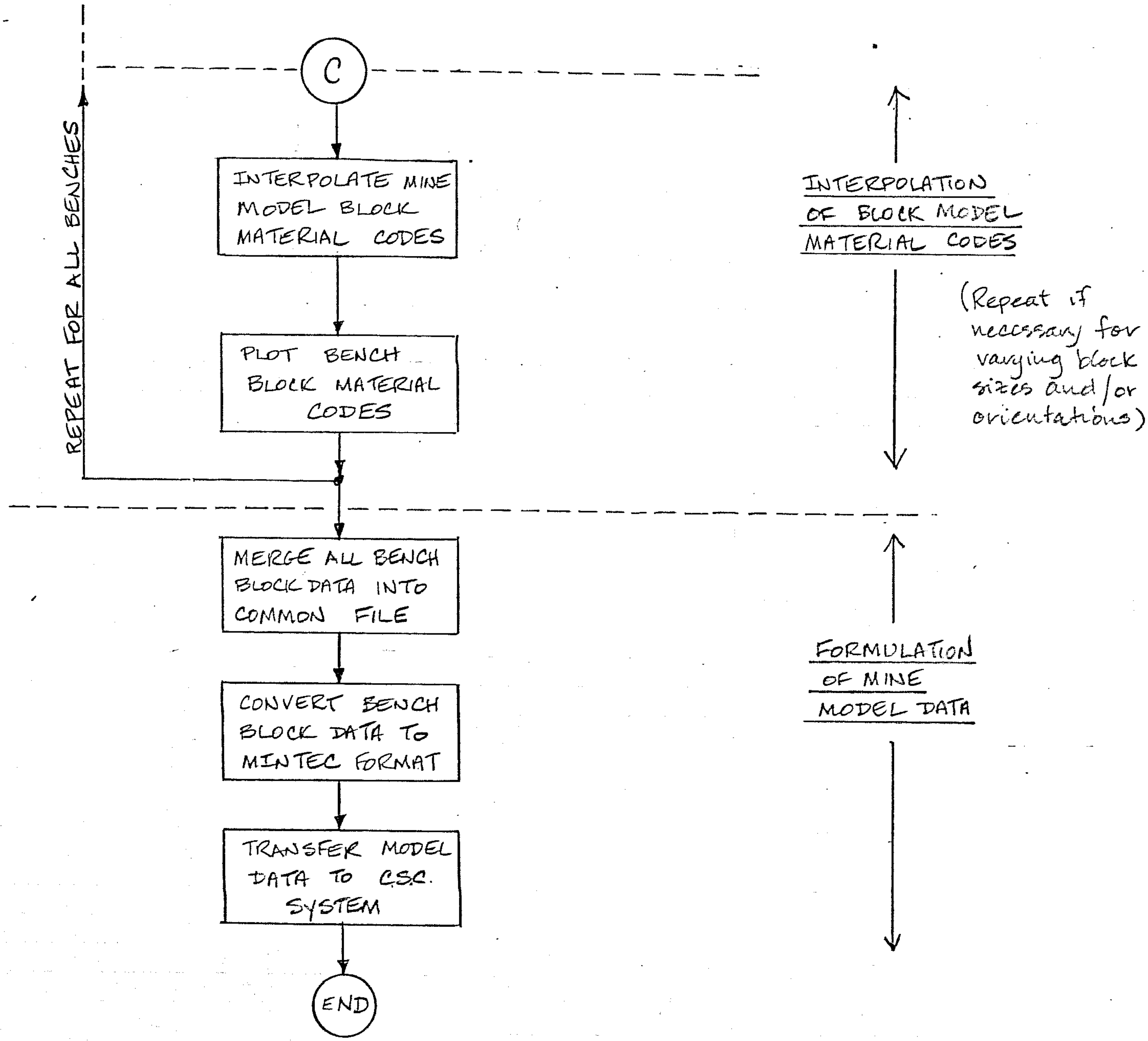

Figure 25 PROPOSED SYSTEM FLOWCHART (Continued)

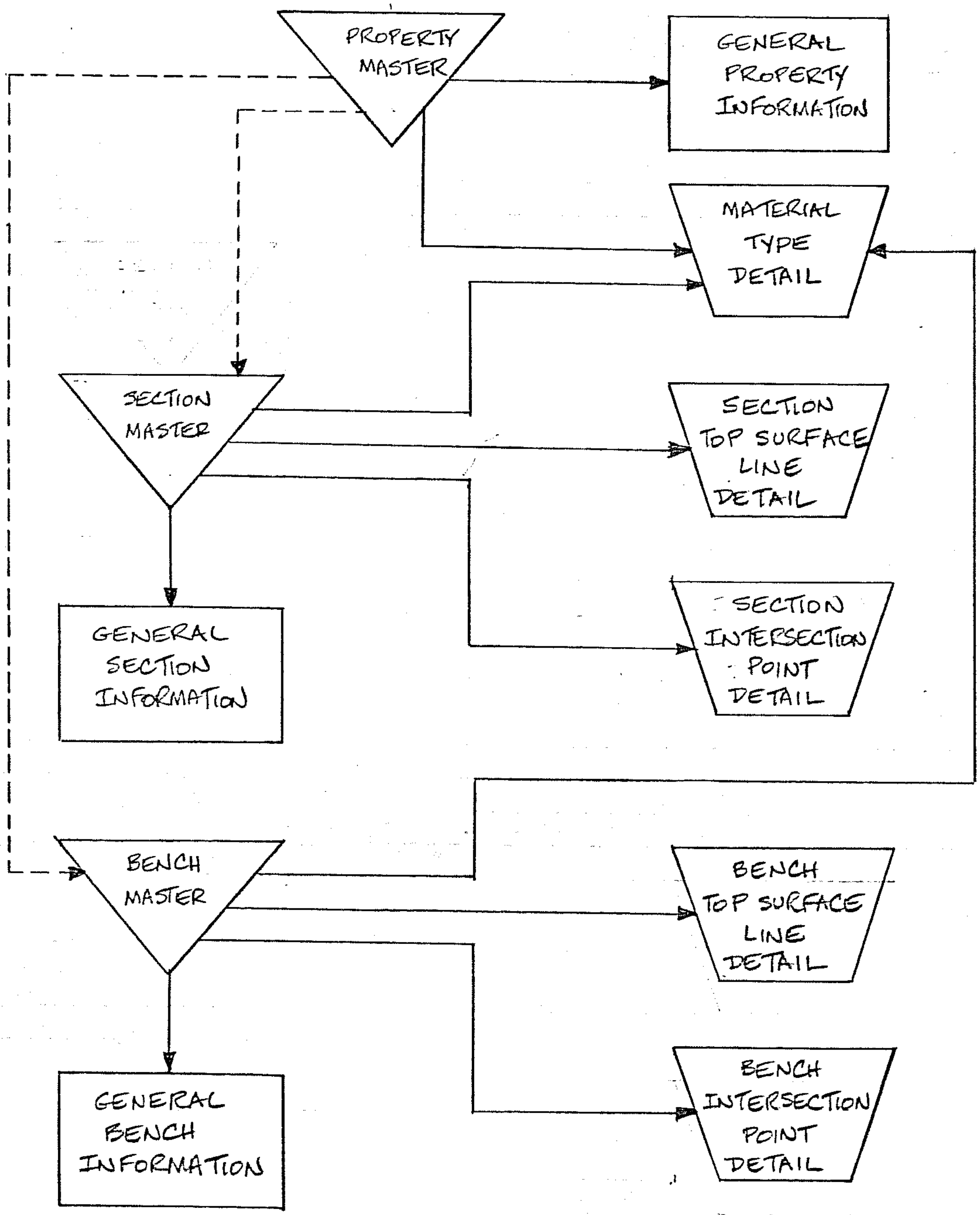

Figure 26 CONCEPTUAL DATA BASE LAYOUT

3.2 System Requirements

The development of the proposed system for generation of mine block model parameters involves the integration of the following components or resources:

1. Computer Hardware.
2. Graphics Devices (graphics hardware).
3. Operating Systems Software.
4. User Interface Software.
5. Applications Software.

The combination of these components, so that operation of the system is consistent, coherent and sensible, is vital and the importance of the integrated nature of these components cannot be over-stated.

The Hewlett-Packard HP-3000 mini-computers currently installed in Faro and Vancouver offer standard computer hardware and operating systems software. Hewlett-Packard also offers or supports a number of interactive graphics devices, such as CRT terminals, plotters and other hardcopy devices. User interface software is generally provided for such graphics devices either by or through Hewlett-Packard. The hardware and operating system software components needed for development of the proposed system are itemized in Table I. This list also includes an optional interactive graphics terminal which, while not absolutely necessary, would provide significant user-oriented facilities for operation of the system and would materially improve computing performance. A review of such terminals is currently being carried out and, in due course, a separate report will be prepared for Cyprus Anvil.

It may be presumed that the above resources can be (and are) integrated in such a manner that only the last component, namely 'Applications Software', need be developed specifically by Cyprus Anvil. This effort would not be insignificant and should be coordinated with other computer program development work carried out for exploration and mining-oriented departments. In particular, the development of various utility routines (listed in Table II) should be considered as a corporate responsibility as they would be used for a number of separate engineering applications. These utilities would be used as integral sub-components of the programs outlined in the data processing flow chart (Figure 25).

TABLE I

RESOURCES REQUIRED FOR DEVELOPMENT OF PROPOSED SYSTEM

	Status
Computer Hardware Requirements	
• HEWLETT-PACKARD 3000 series 33 Systems (Faro and Vancouver installations)	Installed
• TALOS Digitizing Table (36" x 48" surface)	Installed
• CALCOMP 1051 36" drum plotter	AFE
• HEWLETT-PACKARD Interactive Display Terminal (2641 or 2645)	Installed
or	
• HEWLETT-PACKARD Graphics Display Terminal (2647 or 2648)	?
or	
• TEKTRONIX 1051 or 1054 Graphics Display Terminal	?
• Ancillary hardware for communication of data between main frame HP-3000 and terminal components (i.e. the digitizer and the plotter)	?
Operating System Software Requirements	
• FORTRAN/3000 Compiler	Installed
• IMAGE/3000 Data Base Management System	Installed
• QUERY/3000 Data Base Inquiry	Installed
• KSAM/3000 Keyed Sequential Access Method	Installed
• HP VIEW/3000 Data Entry Subsystem	Installed
• HP 3000 Utilities - EDIT/3000	Installed
- SORT-MERGE/3000	Installed
- FCOPY/3000	Installed
• CALCOMP Plotting Software Library	AFE
• PLOT-10 or PLOT-20 Interactive Graphics Software	?

3.3 System Development Costs and Time

It is not currently realistic to detail development costs and time to develop the system, because:

1. discussion of system attributes and capabilities has been limited to short conversations at Faro and via telephone,

2. priorities for engineering computer program development have not been set, and

3. the capabilities and usability of the HP-3000 computers are not known, as yet, by the author.

This report, as indicated in the Introduction, is intended for use as a basis for discussion within Cyprus Anvil and to initiate guidelines for engineering computing development and coordination. During the period in which it will be reviewed by Cyprus Anvil personnel, the author will be attending training sessions on the HP-3000 computer and will also be experimenting on the Vancouver installation. It is hoped that by mid-July, 1980, both Cyprus Anvil personnel and the author will be in a position to discuss the proposed system development and related activities in detail.

TABLE II

UTILITY SOFTWARE DEVELOPMENT REQUIRED

U.1 TALOS DIGITIZER/HP-3000 INTERFACE (APPLICATIONS PROGRAM)

- a program to accept digitized data from the Talos digitizer installed in the Faro engineering office and store it on the HP-3000 in a format convenient for access by the proposed system:
  - will identify points and lines and subsequently store in appropriate fashion;
  - if an interactive graphics terminal is acquired it will run it to display the digitizing action;
  - will perform scaling and coordinate transformation if needed.

(This program will be required by other applications at Faro and thus need not be developed specifically for the proposed system.)

U.2 DIGITIZED POINT PLOTTING ROUTINES

- one version to plot points on incremental plotter (Calcomp in Faro, Houston Instruments at Tetrad in Vancouver);
- second version to plot points on interactive graphics terminal if one is acquired.

U.3 DIGITIZED LINE PLOTTING ROUTINES

- one version to plot digitized lines on incremental plotter;
- second version to plot digitized lines in interactive graphics terminal if one is acquired.

U.4 DIGITIZED POINT AND LINE CORRECTION PROGRAM

- programmed version depends on available hardware;
- allows geologist/engineer to edit and correct digitized point and line data files.

U.5 VERTICAL SECTION PLOTTING PROGRAM

- to prepare formal drawings of vertical sections complete with borders, title block, legend, annotations, elevations and grid value marks.

(This program will be required for other applications of Cyprus Anvil and thus need not be developed specifically for the proposed system.)

TABLE II

UTILITY SOFTWARE DEVELOPMENT REQUIRED - (Continued)

U.6 HORIZONTAL SECTION PLOTTING PROGRAM

- to prepare formal drawings of horizontal plans complete with borders, title block, legend, annotations and grid lines.

(This program will be developed from the existing HRZPLT program developed for the plotting of the Faro deposit mine block models. It will have general use by Cyprus Anvil, both in Faro and Vancouver, and thus need not be developed specifically for the proposed system.)

U.7 PLOT PREVIEW PROGRAM

- only required if an interactive graphics display terminal is acquired by Cyprus Anvil;
- to display on the terminal screen, a scaled-down version of an incremental plotter drawing (or portion thereof) for operator previewing and approval.

(This program would be required for general use by Cyprus Anvil, and thus need not be developed specifically for the proposed system.)

U.8 GRAPHICS Subroutine PACKAGE

- one version required (with two subsets of some sub-routines) for plotting on incremental plotters in Faro and Vancouver;
- second version required if an interactive graphics display terminal is acquired by Cyprus Anvil.

(This package would be required for general use in any event.)