COMPUTER PACKAGES FOR ROAD DESIGN

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FRAME Group

Computer aided design software for low volume roads was originally developed by the US Forest Service in the early 1970's. The emphasis of the software tools was on route location, and the early programs made use of topographic data digitized off contour maps. This allowed a harvesting/roading planner to investigate numerous route options and choose the most suitable alignment. This was particularly important in the Pacific North West where high roading and logging costs could be reduced by careful roading and landing location.

The original software was written exclusively for Hewlett Packard desktop calculators and peripheral equipment which limited its portability to other systems. Since then the popularity of microcomputers using the MS-DOS operating system has resulted in a number of North American software packages being developed for forest engineering applications. The US Forest Service also revised its software into a suite of programs called LVRDS (Low Volume Roads Design System) suitable for MS-DOS microcomputers. Unfortunately none of these software packages are particularly suitable for New Zealand applications due to lack of software support and the different surveying techniques and terminology used in North America. Prices may also be daunting. To make full use of the available software users would need to purchase a forest engineering workstation comprising a computer, digitiser, plotter and printer.

Two Australian developed packages (CIVILDES and SURVIS) are available in New Zealand and although they contain road design schedules they are more suitable for a consultant or local authority involved in urban road design, subdivision, surveying and drainage work. The cost of the package would depend on the number of modules purchased. Neither package makes use of a digitiser and consequently neither has a topographic map data entry facility for assessment of road locations.

Over the last few years the Forest Research Institute at Rotorua has been developing a road design package (ROADS) which is a modified version of the US Forest Service software. The programs were developed for use on the Forest Service's VAX network but corporatisation and the demise of the engineering division has necessitated a revision of the programs. The software is currently being modified for use on MS-DOS microcomputers, but still requires the use of a digitiser and plotter. The package has a number of data entry options and is based on current New Zealand surveying techniques and road design methods. This package would be the most suitable for use in New Zealand.

BENEFITS OF COMPUTER AIDED DESIGN

In North America computer aided design software has been used primarily in the evaluation of timber access road alternatives. In the harvest planning stage the facility to quantitatively evaluate a number of alternative routes in terms of grade, horizontal and vertical alignment and earthwork quantities, and relate the routes to landing sites and harvesting volumes enables the planner to produce an efficient and cost effective harvest plan.

Although the FRI software has the capability to capture data off topographic maps the lack of detailed (1:5000, 5 m contours) maps of forest areas in NZ limits the usefulness of the software. However, for particularly important jobs such as an arterial road bypass the cost of getting a corridor of land mapped by the Department of Survey and Land Information will be extremely cost effective. This would enable a designer to evaluate several alignments within the corridor without going to the expense of detailed ground surveying until the final alignment has been determined. In this case the corridor could be mapped at a more useful scale of 1:2000 with 5 m contours. Ground inspection will of course still be necessary to check on ground features such as streams, rock outcrops, soil types etc.

While it is possible to manually evaluate several route alternatives within a corridor of interest it is an extremely tedious process, and anyone who has manually designed a road will realise how time consuming and tedious it is to make changes to the first design. In many instances the first alignment becomes the final alignment, or no design is done at all.

Computer packages for road design therefore have an important application to the design of new arterial routes, and also for the upgrading of both county roads and forest roads for logging traffic. By quantifying the extent of the work to be done better cost estimating and job control can be achieved.

The FRI package in particular can be integrated with the FRI/ CSIRO truck simulation model. With truck simulation modelling, the effect of changes in grade, horizontal curvature, speed restrictions etc, can be related back to changes in travel speed and time, fuel consumption, braking and gear changes, and ultimately truck operating costs. In this way CAD can be effectively used to quantify the benefits of upgrading existing roads or building new roads.

THE DESIGN PROCESS

All the computer aided road design packages that I have come across follow a similar design process. Topographic data in the form of x,y,z coordinates forms the raw material for all road design. This data is obtained indirectly from a field survey or directly from a digitised contour map.

The electronic plotter, an essential ingredient in any CAD system is used to generate a drawing (plot) of the survey traverse. The horizontal alignment of the designed road is defined by horizontal intersection points and circular curve radii within the bounds of the cross-section corridor. IP's and curve radii may be entered from the keyboard or digitiser keypad. The designer may do as many trial alignments as required to achieve a suitable alignment. Generally the final horizontal alignment would not be finalised until after at least one full design has been completed.

Vertical alignment design is based on the profile plot of the designed horizontal alignment. Both vertical intersection points and curve starting points are entered either from the keyboard or digitiser keypad.

Earthwork calculations are based on the end area formula and the road template at each survey peg. Program information required such as formation width, compaction factors, batter slope ratios etc is entered through the keyboard.

If the horizontal alignment, vertical alignment, road templates and earthwork quantities are satisfactory then the design process has been completed. However the advantage of CAD is that if the design is unsatisfactory then it is a simple matter for the designer to do any number of designs until he or she is satisfied that the best alignment has been obtained in terms of topography, geometric criteria, budget constraints etc.

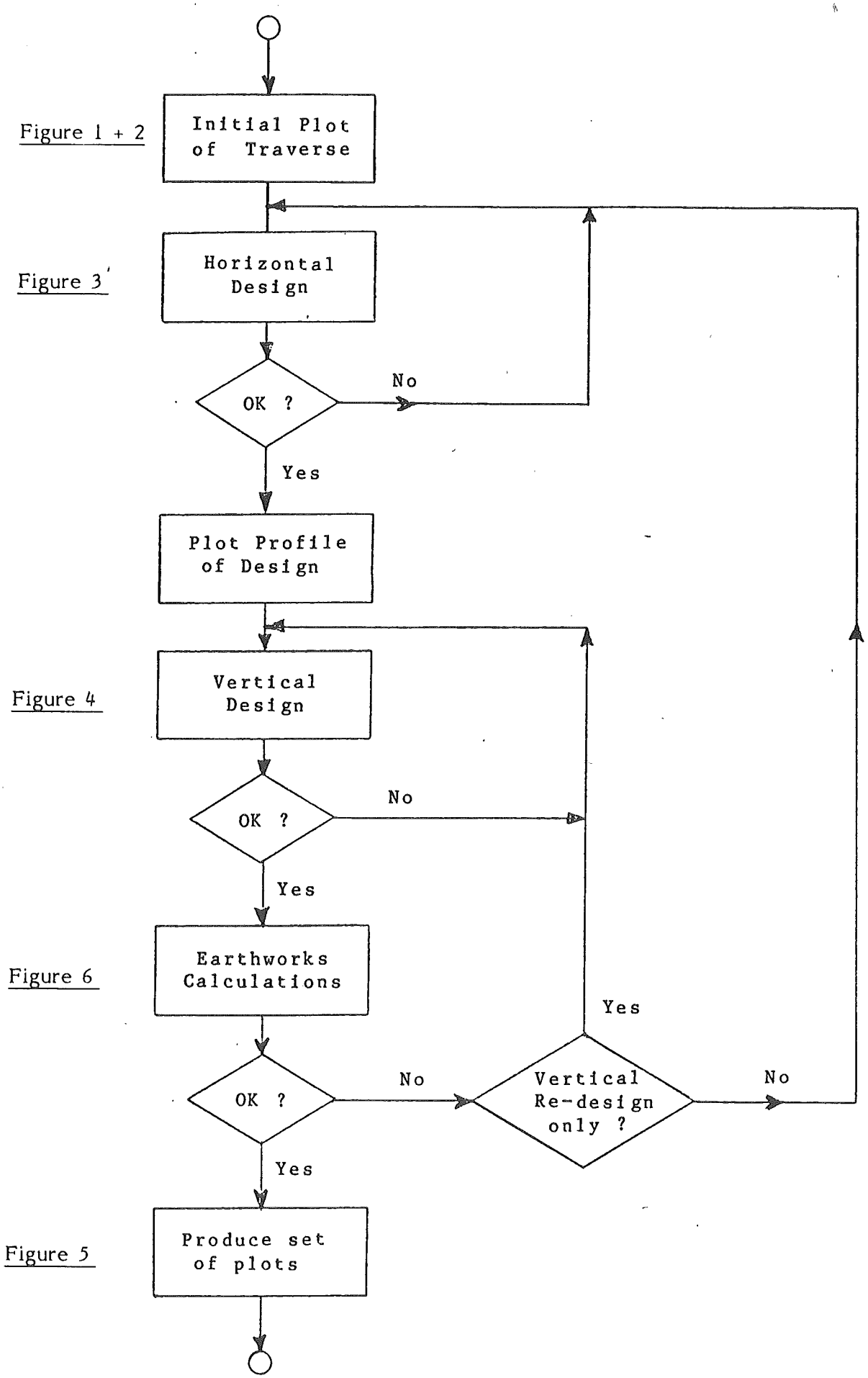


Figure 1 + 2
Initial Plot of Traverse
Figure 3
Horizontal Design
OK ?
No
Yes
Figure 4
Plot Profile of Design
Vertical Design
OK ?
No
Yes
Figure 6
Earthworks Calculations
OK ?
No
Vertical Re-design only ?
Yes
No
Yes
Figure 5
Produce set of plots

Figure 1 - Survey Traverse

PROJECT NAME :MT MESSENGER RE-ALIGNMENT
FOREST LOCATION :WHITECLIFFS SF
DATE :4 SEPT 85
HORIZONTAL SCALE :1:2000
ROTATION ANGLE :340 degrees

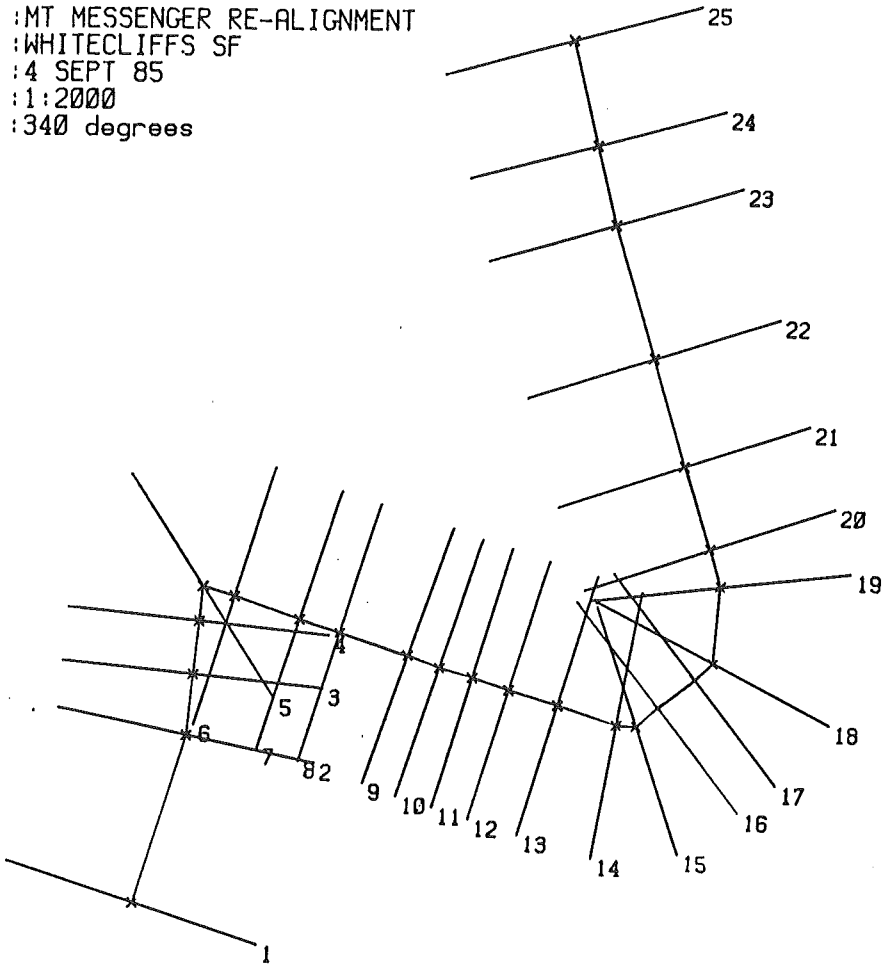
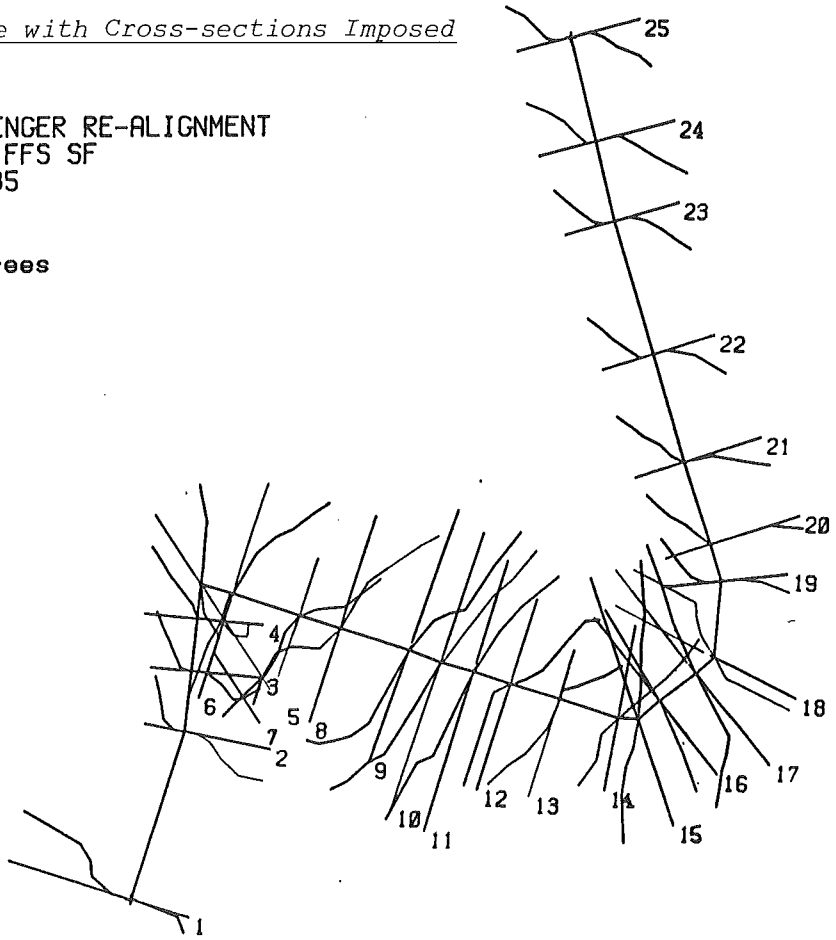


Figure 2 - Survey Traverse with Cross-sections Imposed

PROJECT NAME :MT MESSENGER RE-ALIGNMENT
FOREST LOCATION :WHITECLIFFS SF
DATE :4 SEPT 85
HORIZONTAL SCALE :1:2000

ROTATION ANGLE :340 degrees



PROJECT NAME	:MT MESSENGER RE-ALIGNMENT
FOREST LOCATION	:WHITECLIFFS SF
DATE	:4 SEPT 85
HORIZONTAL SCALE	:1:2000
ROTATION ANGLE	:340 degrees
ROAD LENGTH	:534 metres
HORIZ. PLAN REF.	:1

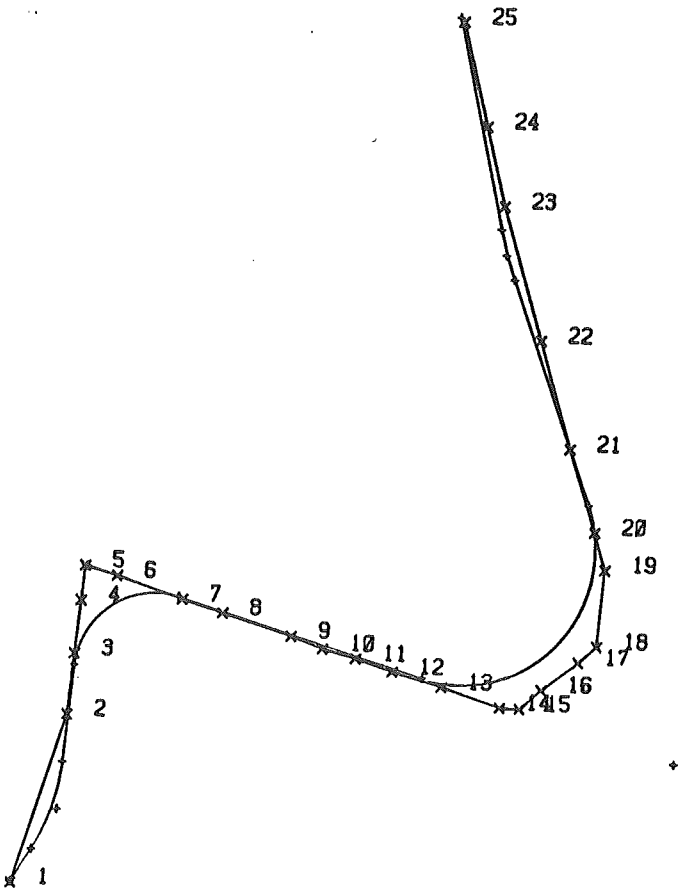


Figure 3 - Horizontal Alignment Super-imposed on Traverse

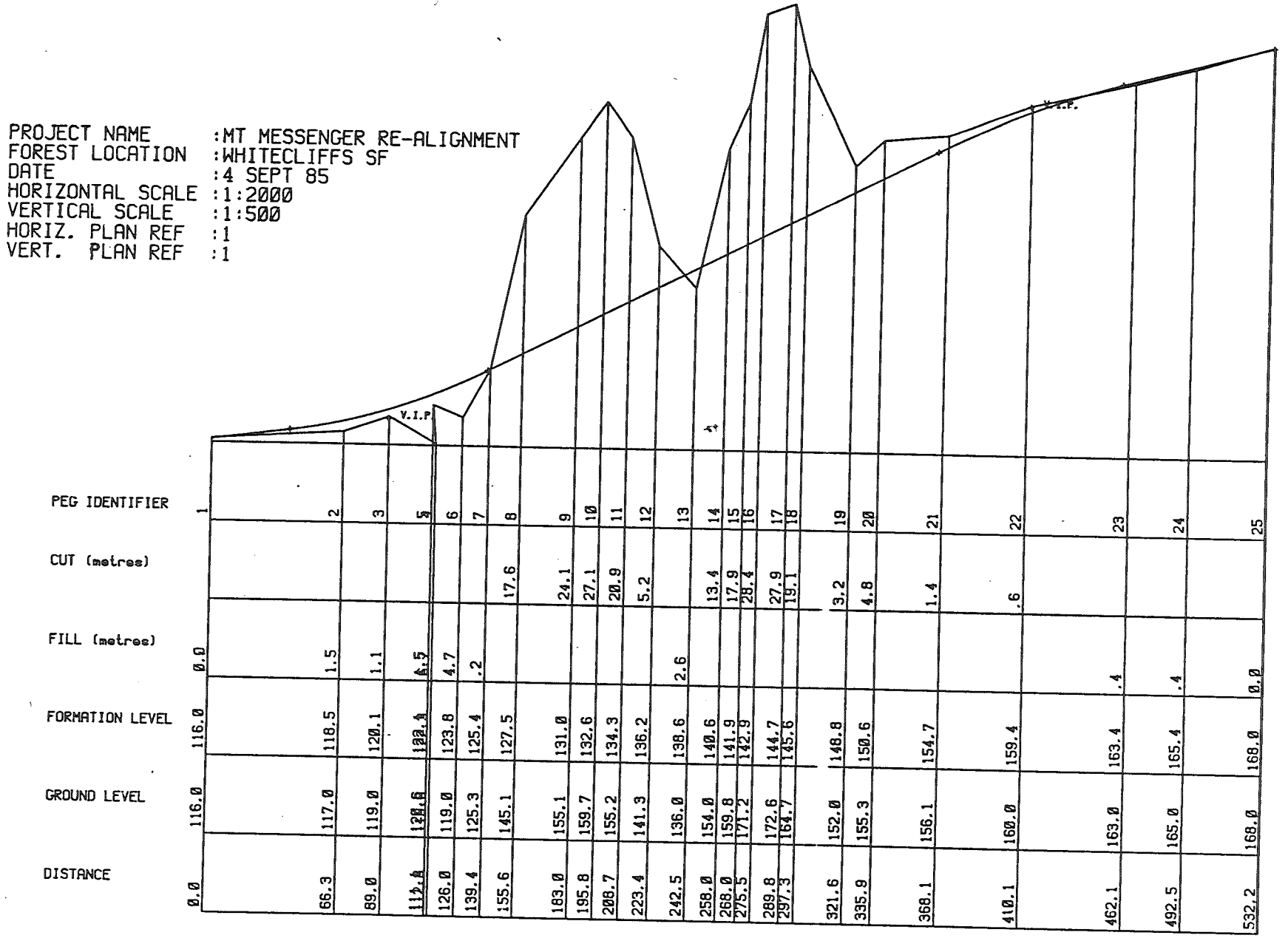
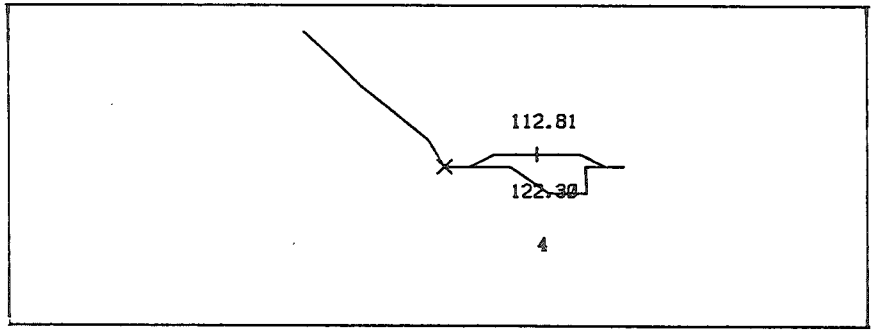
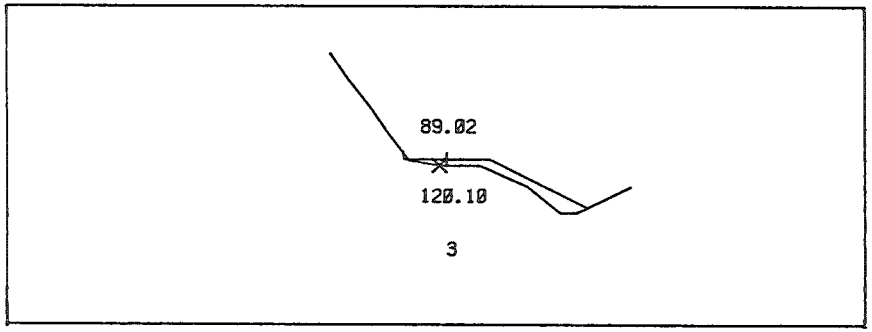


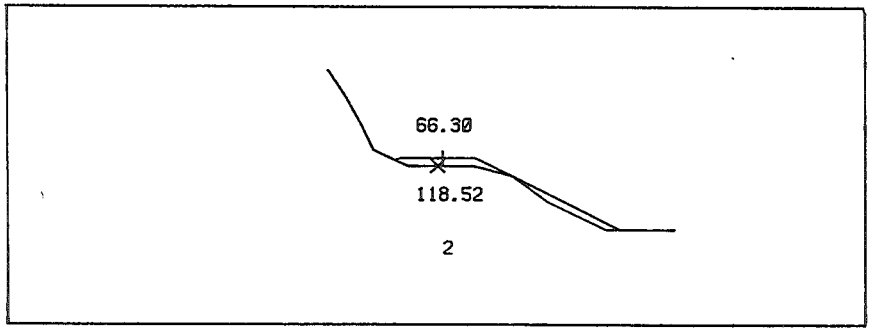
Figure 4 - Vertical Alignment Super-imposed on Profile

PROJECT NAME : MT MESSENGER RE-ALIGNMENT
FOREST LOCATION : WHITECLIFFS SF
DATE : 4 SEPT 85

HORIZONTAL SCALE: 1:750
VERTICAL SCALE: 1:1000
PAGE NUMBER : 1







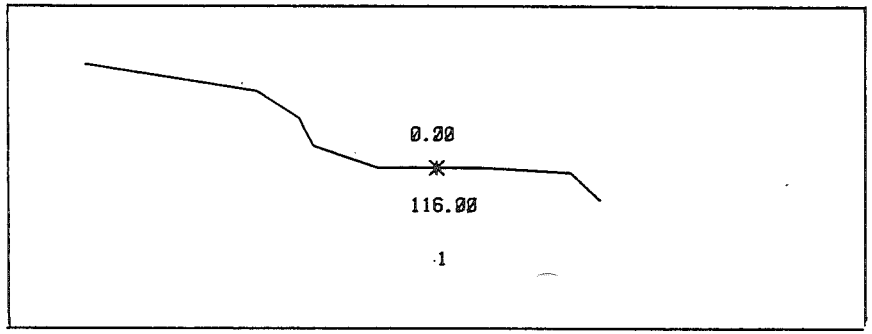
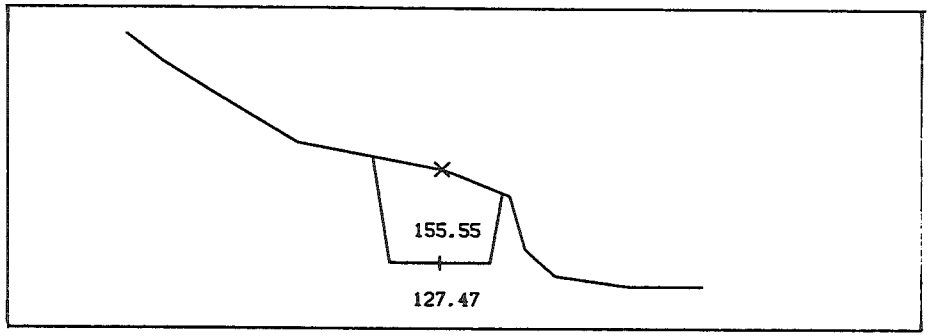
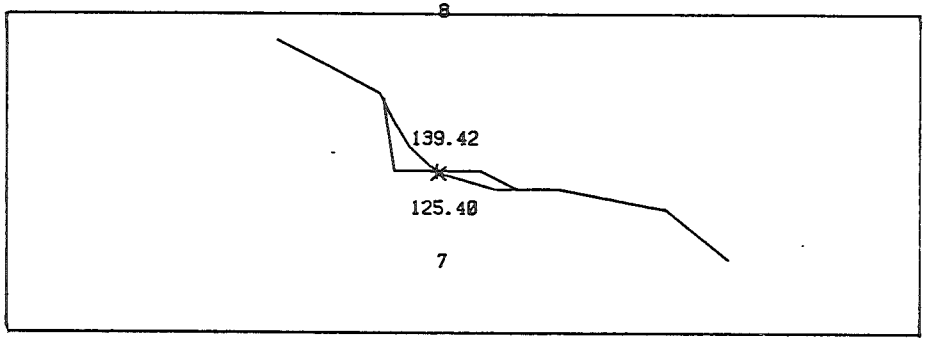


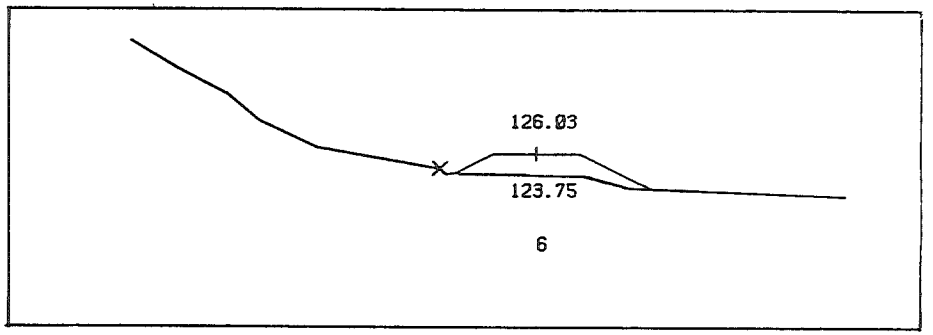
Figure 5 - Cross-sections

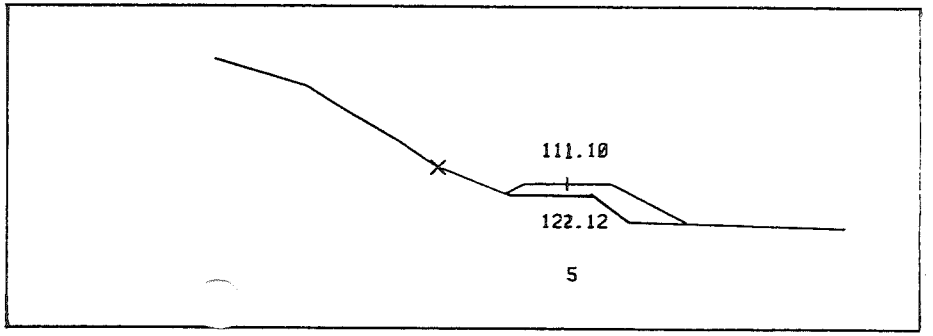
PROJECT NAME : MT MESSENGER RE-ALIGNMENT
FOREST LOCATION : WHITECLIFFS SF
DATE : 4 SEPT 85

HORIZONTAL SCALE: 1:750
VERTICAL SCALE: 1:1000
PAGE NUMBER : 2









PROJECT NAME :MT MESSENGER RE-ALIGNMENT
FOREST LOCATION :WHITECLIFFS SF
DATE :4 SEPT 85
HORIZONTAL SCALE :1:2000
VERTICAL SCALE :1:6000

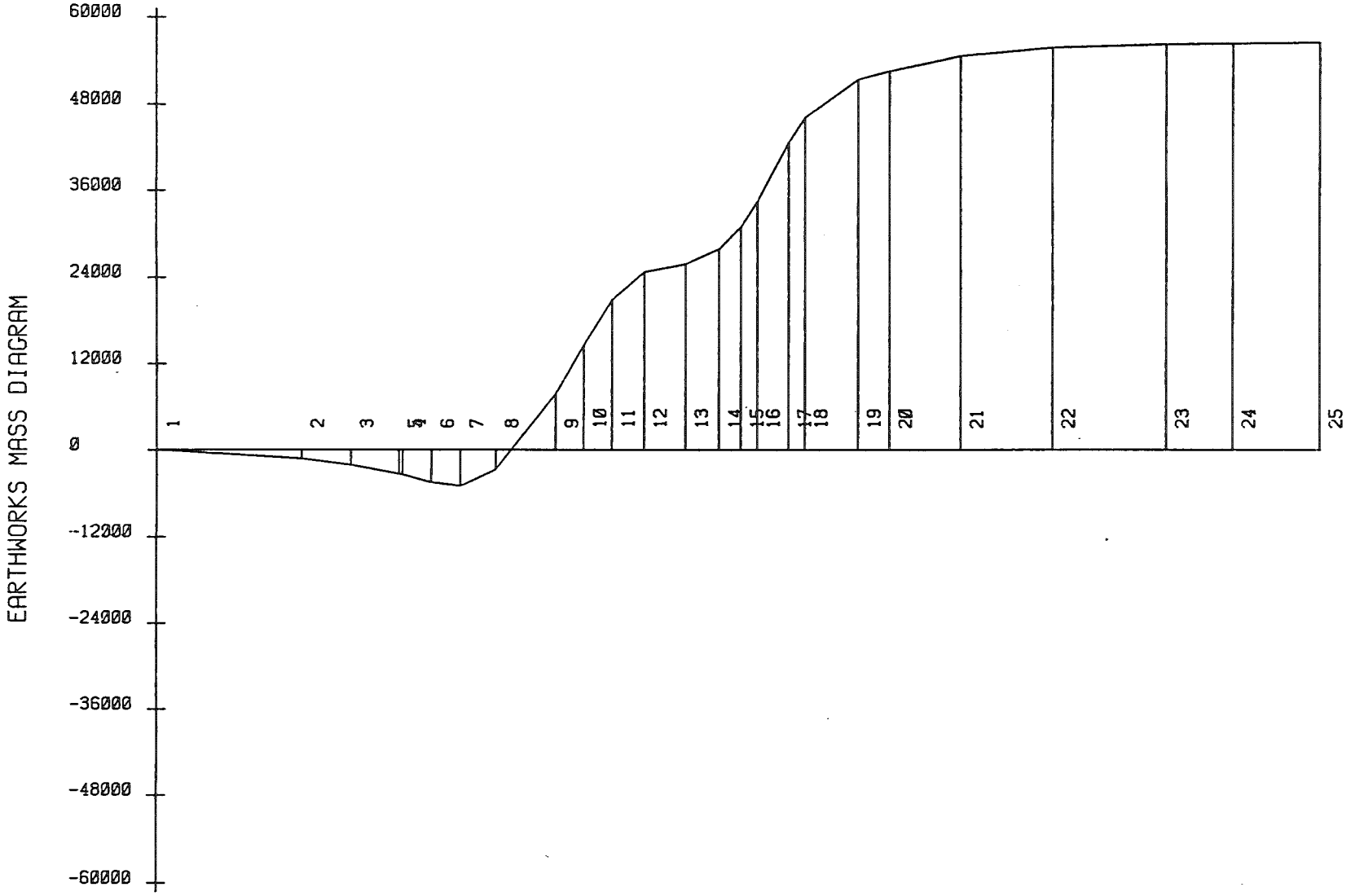


Figure 6 - Mass Diagram