Application of the hypsometric integral and other terrain based metrics as indicators of catchment health: A preliminary analysis

Trevor I. Dowling, D.P. Richardson, Aisling O’Sullivan, Greg K. Summerell and Joe Walker

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Technical Report No 20/98, April 1998
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1. INTRODUCTION

This report documents the terrain analytical techniques and landscape metrics developed as part of the project ‘Evaluating the success of tree planting for degradation control’ (Walker et al., 1998a). The aims of the study were to assess the effectiveness of farm scale tree plantings on landscapes, and in particular for salinity management. It involved three phases:

1) A perception study – through landholder perceptions assess how well trees perform in land degradation control.
2) Measurement study – through field measurements, and guided by phase 1, check the accuracy of landholder perceptions in phase 1 and
3) Validation study – validate the conclusions from phases 1 and 2. The validation study was further divided into:
   a) which species and how many trees are needed to have a measurable effect on the targeted issue
   b) define ‘easy to use’ metrics or parameters to aggregate into an estimate of catchment health
   c) investigate landscape metrics useful in classifying catchments to assist meaningful comparisons.

This report relates to phases 2 and 3 of the project and uses the National Tree Survey (NTS) data set which focused on small catchment sizes (100’s hectares), and the Catchment Health Study (CHS) data set which focused on large catchments (100 000’s hectares). The purpose here is to:

- document the methods used to develop alternative indicators of catchment health for the NTS and CHS studies
- investigate whether biophysical indicators could be used to quickly characterise catchments with respect to susceptibility to dryland salinisation.

A central theme in developing terrain based indicators of catchment health is to benchmark and monitor the condition of land and water resources within catchments (Walker and Reuter, 1996). Although essentially static, the topographic characteristics or morphometry of a catchment can have a substantial impact on how a catchment will respond to land use changes, relative to other catchments. Biophysical condition, the basic character of a catchment, together with land use management controls key water quality degradation issues such as salinity, sedimentation and nutrient transport. Typical indicators of catchment health include stream electrical conductivity (EC), stream turbidity and tree cover. Although the broad aim of both studies was to assess the effect of tree cover on catchment health, this part aimed to explore the contribution biophysical indicators could provide.

Several terrain based metrics were considered together with other data sources to explore potential indicators of catchment health that could be easily acquired for any location in Australia. The main interest was in the hypsometric integral however several other metrics were used and investigated for their applicability to landscape function analysis and catchment characterisation studies.
This report describes an automated implementation of a hypsometric analysis for small size and large size catchments, and some observations of other metrics or indices that were investigated. The emphasis is on fast and achievable estimates rather than definitive answers requiring large volumes of data and resources. The algorithms were developed to run in the ArcInfo Geographic Information System (GIS).

Hypsometric, or area–altitude analysis, relates horizontal cross sectional area of a drainage basin to the relative elevation above the basin mouth, and was first described by Strahler (1952). The hypsometric integral is appealing because it is a dimensionless parameter and therefore allows different catchments to be compared irrespective of scale. It integrates three dimensions, combining area on the x-axis with elevation on the y-axis. The result was described by Strahler as a measure of the erosional state or geomorphic age of the catchment. In theory hypsometric values range from 0 to 1 (in this study the range was from 0.19 to 0.67). Low values are interpreted by Strahler to represent old eroded landscapes, and high values as young, less eroded landscapes. The use of hypsometric analysis has been restricted in the past because of the intensive computation required. Strahler acknowledged that for the effort involved (using a planimeter) it would be more efficient to make a visual assessment of the contours. However, with the advances in computing and GIS technology since 1952, hypsometry is worth reinvestigating as a means of objectively quantifying catchment characteristics.

Other metrics investigated were circularity, catchment area and perimeter length. Circularity can be interpreted in terms of salinity hazard. That is, catchments that approach a circular shape are more likely to behave differently to long linear networks. They tend to be slow flowing, have depositional layers and low gradients and more prone to salinisation. Linear catchments tend to have faster channel drainage and are less prone to salinisation.
2. METHODS

2.1 General

The analyses are described in two parts. The first is an analysis of 47 catchments (6.8 – 4,008 ha in area) that were studied as part of a National Tree Survey (NTS) (Walker et al., 1998a). The second is an extension of the NTS called the Catchment Health Study (CHS) where 7 much larger pilot areas (48,000 – 663,000 ha.) were studied in conjunction with rapid survey techniques for assessing percentage tree cover, stream salinity / turbidity and general health estimates.

Calculation of the hypsometric integral (i.e. the area under the hypsometric curve) was automated in ArcInfo Macro Language (AML) using the TOPOGRID and hydrologic functions available in GRID (ESRI 1995). A contour interval of 10m was chosen for both analyses primarily because it was the input contour interval of the first catchments studied and allowed for direct comparison with manual planimeter methods. It also provided enough elevation ranges for the average relief to give smooth hypsometric curves without compromising processing times. The latter is normally the main criterion for the choice of contour interval.

The method, involving summing cells above contours, is very forgiving of poor quality data in that it will work with any DEM for any area and does not need to be a defined catchment. A hydrologically sound DEM is not critical, however, the quality of the analysis is linked to the quality of the DEM therefore large errors are reflected the results accordingly.

Other catchment metrics, with potential to refine and add to the description and classification while maintaining the simplicity and speed of the approach were investigated. One method comparing area-perimeter ratios for catchments to that of a circle and is described.

A circularity index was calculated as follows:

\[
\text{circularity} = \frac{\text{perimeter}^2}{\text{area}}
\]

The circularity of a circle calculated in this way is \(4\pi\) or 12.5. Similarly the circularity of a square calculated in this way is 16.0.

Similar relationships were explored for rectangles and ellipses but are not reported here. Hypsometric and circularity indices were compared with stream electrical conductivity measurements at catchment outlets. This could be repeated on other factors, e.g. turbidity and subjective health classes or other indicators to test for further relationships.
2.2 Data from the National Tree Survey (NTS): small catchments

The NTS aimed to assess the success of tree planting for the amelioration of land degradation in heterogeneous landscapes. While the NTS was intended to have National application, the fieldwork was limited to 48 mainly first order catchments in NSW between Canberra, Wagga and Forbes. This was reduced to a subset of 14 sites where more reliable EC measurements taken in Creeks or gullies and (with the exception of 1 site) very low tree cover. EC, whilst easy to measure at a point, can vary greatly depending on the flow rate and volume of water in the streams and the timing of the measurement. Reliability here refers to measurement times that coincided with low flows on the hydrograph. *EC is taken as the indicator of degradation in this analysis.*

Catchments were defined as the smallest complete watershed possible that encompassed the tree lots being sampled, that is, down to a point on a watercourse where all drainage affected by the tree lot was accounted for. DEMs were not available at appropriate resolutions so a rapid method for generating DEMs was developed. They were derived using contours, streams and catchment boundaries digitised from the best resolution maps available (usually 1:25000 or 1:50000) and interpolated using ANUDEM (Hutchinson, 1989). A grid resolution of 20mx20m was chosen on the basis of manageability, appropriateness for the resolution of the input data and for the scale of the processes being measured in the overall study. Appendix 1 is a summary of the process used in the NTS study to derive DEMs quickly from minimal data. Appendix 2 is a listing of the automated hypsometric program which consists of three linked AMLs for accumulating cells between contours, processing the resulting tables to derive required parameters and plotting the results.

2.2 Data from the Catchment Health Study (CHS): large catchments

This study focused on rapid sampling techniques for health assessment of large catchments using spatially sparse but well selected sites that could be sampled more frequently. The objective was to develop methods for monitoring catchment health related characteristics that would require only 1 day per catchment (up to 500,000 ha.). Measurements were taken for electrical conductivity (EC) and turbidity of streams, stream flow rate and trials of subjective health measures in the field. Various methods of obtaining percentage tree cover estimates from air photos or satellite imagery were also tested in the laboratory and an order of precedence defined with air photos preferred to satellite classifications and then field estimates.

An existing DEM was obtained for this work at 9 second or approximately 250m resolution (AUSLIG, 1997). This was the best available and appropriate for very large catchments. Catchment boundaries were obtained (CaLM, 1996) together with other ancillary coverages of hydrography, roads, place names etc from digital 1:250000 topographic data series (AUSLIG, 1996). Hypsometric analysis and calculation of the shape indices were performed in the same manner as the NTS catchments except that ancillary data was obtained separately or generated from the
DEM. These indices were compared with sampled EC measurements and tree cover estimated from available sources.

Appendix 2 lists the automated hypsometric program which is the same as that for the NTS in three linked AMLs.

### 3. RESULTS AND VISUALISATION:

**Small catchments (NTS)**

A typical site visualization and summary for an NTS catchment is presented in Figure 1(a-n). It shows a site map of the digitised data in the upper portion of the page and a summary of results from the hypsometric analysis program in the lower portion. The summary includes:

1. the hypsometric curve;
2. statistics for the catchment including integral (area under the curve), average slope, volume under the curve, minimum and maximum elevations, area and contour interval used;
3. a graph of the cumulative mean belt width (i.e. actual mean slope);
4. a location map showing the context of the catchment relative to the extent of the input data.

The hypsometric integrals for all the NTS catchments ranged from .180 to .672, with 1 in the youthful phase, 30 in mature phase and 16 in very old phase. Table 1 shows results for the 14 sites considered to have the most reliable EC measurements. These data suggest that hypsometric integral is not related to any of the measures, especially EC. Some plots are given to illustrate the general lack of relationships (Figures 2 to 6).
Figure 1a. Site 1 results.
Figure 1b. Site 11 results.
Figure 1c. Site 12 results
Figure 1d. Site 21 results.
Figure 1e. Site 23 results.
Figure 1f. Site 40 results.
Figure 1g. Site 48 results.
Figure 1h. Site 50 results.
Figure 1i. Site 52 results.
Figure 1j. Site 53 results.
Figure 1k. Site 54 results.
Figure 11. Site 55 results.
Figure 1m. Site 62 results.
Figure 1n. Site 65 results.
<table>
<thead>
<tr>
<th>Site No.</th>
<th>Hyps. Integral (deg)</th>
<th>Av. Slope</th>
<th>Area (ha.)</th>
<th>Perimeter (m)</th>
<th>Circularity</th>
<th>Min Elev</th>
<th>Max Elev</th>
<th>Tree cover (%)</th>
<th>EC (us/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>48</td>
<td>.672</td>
<td>4.2</td>
<td>17.8</td>
<td>1,757.7</td>
<td>17.39</td>
<td>587</td>
<td>624</td>
<td>10</td>
<td>2300 g</td>
</tr>
<tr>
<td>50</td>
<td>.535</td>
<td>3.1</td>
<td>199.9</td>
<td>6,843.6</td>
<td>23.46</td>
<td>574</td>
<td>643</td>
<td>2</td>
<td>1200 c</td>
</tr>
<tr>
<td>12</td>
<td>.516</td>
<td>4.4</td>
<td>10.0</td>
<td>1,724.8</td>
<td>30.03</td>
<td>336</td>
<td>380</td>
<td>5</td>
<td>76 g</td>
</tr>
<tr>
<td>62</td>
<td>.495</td>
<td>3.2</td>
<td>609.7</td>
<td>10,021.8</td>
<td>16.48</td>
<td>365</td>
<td>481</td>
<td>1</td>
<td>1776 c</td>
</tr>
<tr>
<td>1</td>
<td>.480</td>
<td>7.2</td>
<td>6.8</td>
<td>1,615.3</td>
<td>37.30</td>
<td>399</td>
<td>474</td>
<td>90</td>
<td>79 g</td>
</tr>
<tr>
<td>65</td>
<td>.448</td>
<td>3.4</td>
<td>173.7</td>
<td>5,316.7</td>
<td>16.29</td>
<td>359</td>
<td>423</td>
<td>2</td>
<td>1300 c</td>
</tr>
<tr>
<td>21</td>
<td>.425</td>
<td>4.3</td>
<td>60.4</td>
<td>3,101.3</td>
<td>15.91</td>
<td>348</td>
<td>404</td>
<td>1</td>
<td>3636 c</td>
</tr>
<tr>
<td>55</td>
<td>.419</td>
<td>8.7</td>
<td>44.9</td>
<td>3,115.8</td>
<td>21.68</td>
<td>410</td>
<td>523</td>
<td>3</td>
<td>275 g</td>
</tr>
<tr>
<td>11</td>
<td>.407</td>
<td>6.7</td>
<td>1273.0</td>
<td>19,858.3</td>
<td>30.98</td>
<td>229</td>
<td>463</td>
<td>1</td>
<td>779 c</td>
</tr>
<tr>
<td>40</td>
<td>.402</td>
<td>1.6</td>
<td>109.2</td>
<td>4,362.5</td>
<td>17.47</td>
<td>455</td>
<td>501</td>
<td>1</td>
<td>558 g</td>
</tr>
<tr>
<td>23</td>
<td>.355</td>
<td>3.9</td>
<td>94.8</td>
<td>4,371.7</td>
<td>20.14</td>
<td>376</td>
<td>471</td>
<td>3</td>
<td>2430 g</td>
</tr>
<tr>
<td>53</td>
<td>.349</td>
<td>3.1</td>
<td>75.2</td>
<td>3,977.2</td>
<td>21.03</td>
<td>549</td>
<td>602</td>
<td>2</td>
<td>1300 g</td>
</tr>
<tr>
<td>52</td>
<td>.314</td>
<td>3.7</td>
<td>29.5</td>
<td>2,405.5</td>
<td>19.73</td>
<td>517</td>
<td>565</td>
<td>2</td>
<td>1130 g</td>
</tr>
<tr>
<td>54</td>
<td>.191</td>
<td>11.5</td>
<td>136.1</td>
<td>6,171.5</td>
<td>28.00</td>
<td>506</td>
<td>743</td>
<td>1</td>
<td>412 g</td>
</tr>
<tr>
<td>Range</td>
<td>.492</td>
<td>11.2</td>
<td>4001.2</td>
<td>30,242.0</td>
<td>22.5</td>
<td>363</td>
<td>441</td>
<td>89</td>
<td>3560</td>
</tr>
<tr>
<td>Mean</td>
<td>.399</td>
<td>4.3</td>
<td>268.8</td>
<td>5,663.1</td>
<td>19.9</td>
<td>116</td>
<td>127</td>
<td>8.9</td>
<td>1232.2</td>
</tr>
<tr>
<td>Std Dev.</td>
<td>.104</td>
<td>2.42</td>
<td>627.96</td>
<td>5,424.5</td>
<td>4.6</td>
<td>394</td>
<td>535</td>
<td>23.5</td>
<td>1022.2</td>
</tr>
</tbody>
</table>

Table 1. Summary for 14 small National Tree Survey Catchments after poor data and non-creek (c) /gully (g) EC measurements were removed.

![Hypsometric Integral v's EC](image)

**Figure 2.** The hypsometric integral is not correlated with EC
Figure 3. The relationship between circularity and EC is reasonably strong. This reflects the assertion that non-circular catchments are more likely to drain quickly and remove salt.

Figure 4. EC and area are not related
Figure 5. EC and perimeter are not related.

Figure 6. No relationship was detected between EC and tree cover%.

In summary:

- Only circularity and EC (the degradation measure) showed a strong relationship in small catchments.
- The catchment with a high tree cover had the lowest EC value.
- Possibly because of the way they were defined the terrain metrics used are not useful in these small catchments; therefore examining their performance in larger catchments is warranted.
• In addition EC measures are unreliable in small catchments because of the very rapid decline in water flow.
• Tree cover some confounding effects on hypsometric relationships.

The 7 Large catchments (CHS)

The summaries and visualizations of the hypsometric analysis for the 7 large CHS catchments are given in Figure 7. Table 2 summarises the values for all the metrics for the large catchments. The range of hypsometric integral values for the CHS catchments was .152 to .431 with 4 in the mature phase and 3 in the very old phase. Plots are given to illustrate the relationships between EC and metrics (Figures 8 to 12).
Figure 7. Results for the Catchment Health Study hypsometric analysis. Integral is area under the curve; Average slope covers the whole cumulative belt width curve; m^3*10^3 is actually volume of uneroded catchment above the minimum elevation in thousands of cubic metres; Elev is elevation; area is in hectares; and Cntr Int is contour interval used.
<table>
<thead>
<tr>
<th>Catchment name</th>
<th>Hypsometric Integral</th>
<th>Average slope (deg)</th>
<th>Area (ha) (grid)</th>
<th>Perimeter (m)</th>
<th>Circularity (grid)</th>
<th>Min Elev</th>
<th>Max Elev</th>
<th>Tree Cover est. %</th>
<th>Tree Cover est. method</th>
<th>EC (us/cm) spatial mean</th>
<th>CHS pilot</th>
<th>EC (us/cm) at outlet CHS pilot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotter</td>
<td>0.431</td>
<td>11.2</td>
<td>48,213</td>
<td>149,078</td>
<td>46.1</td>
<td>485</td>
<td>1,894</td>
<td>95.5</td>
<td>2,3,4</td>
<td>59</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Jugiong</td>
<td>0.390</td>
<td>5.1</td>
<td>219,696</td>
<td>240,651</td>
<td>26.4</td>
<td>227</td>
<td>830</td>
<td>2.0</td>
<td>5</td>
<td>1731</td>
<td>1300</td>
<td></td>
</tr>
<tr>
<td>Queanbeyan</td>
<td>0.390</td>
<td>6.7</td>
<td>96,875</td>
<td>194,657</td>
<td>39.1</td>
<td>564</td>
<td>1,593</td>
<td>54.0</td>
<td>1,3</td>
<td>216</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>Yass</td>
<td>0.364</td>
<td>3.4</td>
<td>122,453</td>
<td>201,400</td>
<td>33.1</td>
<td>480</td>
<td>921</td>
<td>18.2</td>
<td>3,4</td>
<td>914</td>
<td>710</td>
<td></td>
</tr>
<tr>
<td>Young East</td>
<td>0.348</td>
<td>4.4</td>
<td>164,793</td>
<td>250,000</td>
<td>37.9</td>
<td>264</td>
<td>707</td>
<td>-</td>
<td>-</td>
<td>1,5</td>
<td>1145</td>
<td>1437</td>
</tr>
<tr>
<td>Young West</td>
<td>0.347</td>
<td>4.2</td>
<td>169,028</td>
<td>286,227</td>
<td>48.5</td>
<td>220</td>
<td>716</td>
<td>-</td>
<td>1,5</td>
<td>1584</td>
<td>1580</td>
<td></td>
</tr>
<tr>
<td>Mooki</td>
<td>0.152</td>
<td>9.9</td>
<td>662,875</td>
<td>371,223</td>
<td>20.8</td>
<td>263</td>
<td>1,312</td>
<td>15.0</td>
<td>1</td>
<td>1053</td>
<td>590</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Summary for Catchment Health Study Catchments. Tree cover estimates were made from 1: air photos, 2: Non/wooded classification (Dept. Environment, Land and Planning), 3: satellite image classification (CRC Freshwater Ecology), 4: Satellite imagery (CSIRO, Land and Water) and 5: field estimate. After comparing methods the preferred precedence established was 1,2,3,4,5. The Mooki catchment proved to be anomalous, and this was attributed to its size and internal complexity.

Figure 8. A moderate relationship exists between hypsometric integral and EC.

Compared with the other catchments the outlier (Mooki) was later shown to have different land use patterns and considerable internal heterogeneity with respect to many soil/landscape variables.
Figure 9. At the larger scale circularity was not related to EC, yet it was correlated at the small scale.

Figure 10. The relationship between catchment area and EC is strong.
Figure 11. The relationship between EC and perimeter area is strong.

Figure 12. Data from the large catchment study (CHS) combined with data from a broader survey in similar sized catchments in the Upper Murrumbidgee catchment. This shows a strong relationship between tree cover and EC.

In summary:

- Strong relationships were detected between landscape metrics and EC values for large catchments
- A poor relationship between EC and circularity in the large catchments is the exception, compared with the strong relationship in the small catchments.
• The number of sites limits firm conclusions, but can be considered to be an encouragement for further sampling and analysis.

4. KEY MESSAGES

This paper documents preliminary research on several landscape metrics rarely investigated quantitatively. It represents the beginning of a larger study to classify catchments into different functional types and to apply biophysical indicators to estimate catchment health.

The hypsometric approach developed by Strahler and automated here has promise as a terrain analysis tool for:

• riparian studies (Prosser and Dowling, 1998),
• erosion indices (Prosser and Gallant, unpublished),
• indicators of catchment health (Walker et al., 1998b)
• catchment classification / categorisation generally (Walker and Evans, 1997).
• use as an ‘envelope’ as in the BIOCLIM type modeling that used climatic envelopes for predicting the potential range of plants and animals (Nix, 1986; Busby, 1986)

The methods developed for rapidly determining the hypsometric integral for catchments are useful where a DEM exists, but can be applied easily for smaller areas where only a contour map is available, with greater efficiency, flexibility and less error. Using a planimeter to measure small irregular areas was difficult.

Better correlations between EC and other indices existed in the larger catchments only, suggesting a need to examine the field sampling method, the nature of environmental signal attenuation and influences of areal scale. Sorting out the complex interactions between geomorphic underpinning and land use impacts, including tree planting, represents a major challenge.

For the larger CHS catchments, the removal of 1 outlier catchment resulted in strong relationships between EC and most metrics.

The fact that we could easily identify an outlier suggests there may be a strong potential for identifying anomalous catchments, and this could be useful for classifying catchments into functional types.

Catchment classifications using single terrain attributes as indicators are unlikely to succeed. Applying combinations of indicators in a framework such as an environmental envelope or an aggregated index are worth investigating.
References

AUSLIG (1996) Topo250k Digital Data, Auslig, Canberra, Australia

AUSLIG (1997) 9 second DEM, Auslig, Canberra, Australia


APPENDIX 1. Summary of the Method of Processing NTS catchments

Documentation for deriving DEMs in the NTS topographic assessments:

NOTE: these data sets are intended as rapid assessments only.

T Dowling, CSIRO Div Water Resources, Canberra
15.8.1996 - completion of the work up to and including the hypsometric analysis
23.8.1996 – commencement date for this documentation.

Filename prefixes:       bndnn - boundary for catchment ‘nn’
                        cntnn - contours for catchment ‘nn’
                        lotnn - tree lots in catchment ‘nn’
                        strnn - streams in catchment ‘nn’

STEP 1.1:
1:25000 or 50000 mapsheet -> _STARTDIG.AML -> bndnn
                       ( & cntnn and lotnn and strnn)

STEP 1.2:
Digitised covers -> GETMAP.AML -> copied to appropriate computer,
                       drawn to check,
                       built appropriately
                       (bndnn, cntnn, lotnn, strnn)

STEP 1.3:
Built covers -> TRANS.AML -> asks for min’s & max’s, adds tics,
                       then transforms to AMG
                       (bndntm, cntntm, lotntm, strntm)

                       digitising was quick and dirty - typical input/output RMS of .003/5.
                       some, like on the corner of 4 sheets as bad as .1/11.
                       this wasn't seen as critical for this 'quick look method' and shouldn't
                       be used for anything where high accuracy is important.

STEP 1.4:
transformed covers -> TOPO.AML -> DEM, masks catchment
                       (demnn, masknn, catnn)

STEP 2: Ready to invoke hmetric.aml (see Appendix 2)
Masked DEM -> HMETRIC.AML -> hypsometric calculations for catchment
                       (hypnn.tbl)
APPENDIX 1. (cont) Detailed listings of AML’s used in NTS process.

1.1 Digitising:

run _STARTDIG
- digitise tics (MAP CORNERS, NOTE LONG/LATS for transform later)
- digitise two world points outside map area (aml requirement)
- digitise catch boundaries (ie with auto increment from 1 [default])
- digitise streams following straight on
- digitise contours BUT change id each time to that of contour value
  needs 8 (to get menu up )
  needs 1 (to set id using cursor numbers)
  needs A (to enter number)
  needs 2 (to start line)
  needs 1 (for vertices)
  needs 2 (to end line)
repeat for all contours

1.2 Copying files from digitising computer to appropriate working directory if necessary

Getmap.aml:

&work %work_dir%
&sv grd = [response 'Are we already in GRID ? ( y or n )']
&if %grd% ne 'y' and %grd% ne 'Y' &then
  &do
  grid
  &end
clear
units map

&sv .cnum = [response 'Catchment number to work on ? ( 1 to 56 )']
&if not [ exists c%.cnum% -directory] &then
  &sys mkdir c%.cnum%
&work c%.cnum%
&if [ exists %dig_dir%/bnd%.cnum% -cover] &then
  &sys arc copy %dig_dir%/bnd%.cnum% bnd%.cnum%
&if [ exists %dig_dir%/cnt%.cnum% -cover] &then
  &sys arc copy %dig_dir%/cnt%.cnum% cnt%.cnum%
&if [ exists %dig_dir%/str%.cnum% -cover] &then
  &sys arc copy %dig_dir%/str%.cnum% str%.cnum%
&if [ exists %dig_dir%/lot%.cnum% -cover] &then
  &sys arc copy %dig_dir%/lot%.cnum% lot%.cnum%
&sys arc lc
  mape cnt%.cnum%
  linecolor orange
  &if [ exists cnt%.cnum% -cover] &then
  arcs cnt%.cnum%
  linecolor blue
  &if [ exists str%.cnum% -cover] &then
  arcs str%.cnum%
  linecolor red
  &if [ exists bnd%.cnum% -cover] &then
  arcs bnd%.cnum%
  linecolor green
  &if [ exists lot%.cnum% -cover] &then
  arcs lot%.cnum%
&sv ok = [response 'Ready to work on ? ( GRID will exit )']
&if %ok% eq 'y' or %ok% eq 'Y' &then
  &do
  &if [ exists bnd%.cnum% -cover] &then


&sys arc create bnd%.cnum%tm
&if [ exists cnt%.cnum% -cover] &then
&sys arc create cnt%.cnum%tm
&if [ exists str%.cnum% -cover] &then
&sys arc create str%.cnum%tm
&if [ exists lot%.cnum% -cover] &then
&sys arc create lot%.cnum%tm
&end
q
&work %work_dir%
&return

1.3 TRANSFORMATION
/* [in Arc] create covernametrn */
/* tables */
/* - sel covernametrn */
/* - add */
/* - 1, long, lat */
/* - 2 ... */
/* - 3 ... */
/* - 4 ... */
/* - <ret> */
/* - list (check them) */
/* - q */
/* */
/* arcc: transform covernamedig covernametrn affine */
/* */
/* arccedit: */
/* - ec covernametrn */
/* - ed arc */
/* - save each layer of each catchment to cntxx */
/* (cnt=contours.xx=site no.) */
/* - save each layer of each catchment to strxx */
/* (str=streams.xx=site no.) */
/* - save each layer of each catchment to bndxx */
/* (bnd=boundary.xx=site no.) */
/* */
/* - edit each of these for appropriate data */
/* sel or sel many and delete to edit out as necessary */
/* */
/* trans.aml */
&sv .cnum = [response 'Catchment number to work on ? ( 1 to 56 )']
&work c%.cnum%
/* -=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-= */
&sv .xmin = [response ' Min X ' ]
&sv .xmax = [response ' Max X ' ]
&sv .ymin = [response ' Min Y ' ]
&sv .ymax = [response ' Max Y ' ]
&if [ exists bnd%.cnum% -cover] &then
&do
tables
   sel bnd%.cnum%tm.tic
   add
   1,%.xmin% , %.ymax%
   2,%.xmax% , %.ymax%
   3,%.xmax% , %.ymin%
   4,%.xmin% , %.ymin%
   ~
   q
&end
&if [ exists cnt%.cnum% -cover] &then
&do
tables
  sel cnt%.cnum%tm.tic
  add
    1,.xmin% , .ymax%
    2,.xmax% , .ymax%
    3,.xmax% , .ymin%
    4,.xmin% , .ymin%
  ~
  q
&end

&if [ exists str%.cnum% -cover ] &then
&do
  tables
    sel str%.cnum%tm.tic
    add
      1,.xmin% , .ymax%
      2,.xmax% , .ymax%
      3,.xmax% , .ymin%
      4,.xmin% , .ymin%
    ~
    q
&end

&if [ exists lot%.cnum% -cover ] &then
&do
  tables
    sel lot%.cnum%tm.tic
    add
      1,.xmin% , .ymax%
      2,.xmax% , .ymax%
      3,.xmax% , .ymin%
      4,.xmin% , .ymin%
    ~
    q
&end

&if [ exists bnd%.cnum%tm -cover ] &then
&do
  &sys arc transform bnd%.cnum% bnd%.cnum%tm affine
  &sys arc build bnd%.cnum%tm poly
&end

&if [ exists cnt%.cnum%tm -cover ] &then
&do
  &sys arc transform cnt%.cnum% cnt%.cnum%tm affine
  &sys arc build cnt%.cnum%tm line
&end

&if [ exists str%.cnum%tm -cover ] &then
&do
  &sys arc transform str%.cnum% str%.cnum%tm affine
  &sys arc build str%.cnum%tm line
&end

&if [ exists lot%.cnum%tm -cover ] &then
&do
  &sys arc transform lot%.cnum% lot%.cnum%tm affine
  &sys arc build lot%.cnum%tm poly
&end

&work %work_dir%
&return

1.4 topo2.aml/* Generate a DEM in TOPOGRID

&work %work_dir%
&sv .cnum = [response 'Catchment number to work on ? ( 1 to 56 )']
&work c%.cnum%
shadeset rainbow
&if [ exists dem%.cnum% -grid ] &then
  kill dem%.cnum% all
/*&if [ exists cat%.cnum% -grid ] &then
  /* kill cat%.cnum% all
&if [ exists drn%.cnum% -cover ] &then
  kill drn%.cnum% all
&if [ exists drn20 -cover ] &then
  kill drn20 all
&if [ exists snk%.cnum% -cover ] &then
  kill snk%.cnum% all
&if [ exists snk20 -cover ] &then
  kill snk20 all
&if [ exists cnt%.cnum% -cover ] &then
  kill cnt%.cnum% all
&if [ exists cnt%.cnum%tm -cover ] &then
  kill cnt%.cnum%tm all
&if [ exists diagtm -file ] &then
  &sys rm diagtm
&if [ exists diag20tm -file ] &then
  &sys rm diag20tm
  copy .../c71/dem71 dem%.cnum%
copy .../c71/drn71 drn%.cnum%
copy .../c71/snk71 snk%.cnum%
  &sys cp -p ../c71/diagtm .
copy ../c71/cnt71 cnt%.cnum%
copy ../c71/cnt71tm cnt%.cnum%tm
  mape dem%.cnum%
grids dem%.cnum% # linear nowrap
/*setcell dem%.cnum%
/*setwindow bnd%.cnum%tm
/*mask%.cnum% = polygrid ( bnd%.cnum%tm )
/*cat%.cnum% = con( mask%.cnum% gt 0, dem%.cnum%, setnull(1) )
grids cat%.cnum% # linear nowrap
linecolor orange
&if [ exists cnt%.cnum%tm -cover ] &then
  arcs cnt%.cnum%tm
linecolor blue
&if [ exists str%.cnum%tm -cover ] &then
  arcs str%.cnum%tm
linecolor red
&if [ exists bnd%.cnum%tm -cover ] &then
  arcs bnd%.cnum%tm
linecolor green
&if [ exists lot%.cnum%tm -cover ] &then
  arcs lot%.cnum%tm
&sv ok = [response 'Exit GRID ( n to stay & run hmetric.aml ) ?']
&if %ok% eq 'y' or %ok% eq 'Y' &then
  &do
  q
  &end
&work ..
show work
&return
APPENDIX 2. AML scripts for processing catchment Hypsometrics

Appendix 2.1

/* HMETRIC3v2.AML
/* written 16.04.97...tid
/* to calculate hypsometric curves and call appropriate aml's to plot:
/* addtab2v0.aml - takes tabular output and installs in info table
/* gtab2v0.aml - takes table and plots graph and location map
/* modified 24.04.97...tid
/* changed to accept and extract from a multi-item grid instead of
/* choices of single ones
/* copied to nts/catch/hmetric3v1 prior to 14.6.97; rerun for CHS June writeup
/* copied to nts/catch/hmetric3v2 prior to 14.6.97; rerun for CHS June writeup
/* modified 16.6.97...tid to reflect changes in ~/catch/hmetric3v0.aml,
/* gtab2v0.aml
/* gtabsum3.aml

&messages &off &info
/* set up plotting environment – page layout

shadecolor cmy 0 0 0
shadeput 257
gridnodatasymbol 257
textset font.txt
textsymbol 1

&sv .nperpage = 4
&sv .nperpage = 1
&sv .npt = 0
&sv .npage = 0
&sv .end = .FALSE.

&sv .ci = [response ' Contour interval [10]' 10 ]

&sv runopt = [response 'Table with headers or (g)raph for ArcInfo' t]
/* table is for exporting to excel graph is for graphical output to plot.
&sv runopt = g

/* Select the catchment number to process ...
&ty
&ty Choose the set to analyse from -
&ty
&ty 0. all NTS catchments
&ty 1. specific NTS / CHS catchment(s)
&sv setopt = [response ' Option [1]' 1 ]

&if %setopt% eq 0 &then
&do
/* could automate this with listunique...
&sv nums =
1,3,5,8,11,12,13,14,15,16,17,19,20,21,23,24,25,28,31,34,35,36,37,38,39,40,42,43,44,46,48,49,50,52,5
3,54,55,56,57,61,62,63,65,66,67,68,71
&end
&else
&do
&sv nums := [response ' Catchment number for this run (1 to 56)' ]
&end

&do .cnum &list %nums%

&work %work_dir%/c%.cnum%
mape c%.cnum%
setwindow c%.cnum%
&sv geodataset = c%.cnum%
&sv .outf = hmetric%.cnum%
&sv outf il := %.outf%.tbl

&ty %outfil% %.cnum% : %nums%
&sv i = [close -all]
&if [ exists %outfil% ] &then
 &do
 /* &sv resp = [response 'Delete this file ?' n]
 &sv resp = y
 &if resp eq ’y’ or resp eq ’Y’ &then
 &do
 &ty
 &ty rm’ing %outfil%
 &sys rm %outfil%
 &end
 &end
 &sv file_unit = [open %outfil% openstatus -write]
 &ty open status = %openstatus% (0 = OK)

&sv .catgrd = cat%.cnum%
&sv slpgrd = slp%.cnum%
&if [exists slp%.cnum% -grid] &then
 kill slp%.cnum% all
 slp%.cnum% = slope ( cat%.cnum% )
 describe slp%.cnum%

/* &if [exists %.catgrd% -grid] &then kill %.catgrd% all
 /* %.catgrd% = con ( %geodataset% eq %.cnum%, fil5 )
 shadeset rainbow

&if ^ [exists pol%.cnum% -grid] &then
 pol%.cnum% = gridpoly ( msk%.cnum% )
 setwindow pol%.cnum%

/* Extract vital parameters from the grid ...

&describe %.catgrd%

&sv celldim = %GRD$DX%
&sv dz = %GRD$ZMAX% - %GRD$ZMIN%
&sv .zmin = [truncate %GRD$ZMIN%]
&sv diffmin = [mod %.zmin%, %.ci%]
&sv mincntr = %.ci% - %diffmin% + %.zmin%

&sv .zmax = [round %GRD$ZMAX%]
&sv diffmax = [mod %.zmax%, %.ci%]
&sv maxcntr = %.ci% - %diffmax% + %.zmax%
&sv cntr1 = %mincntr% - %.ci%
&sv cntrn = %maxcntr%
&sv cumarea = 0

/* Extract vital parameters from the grid ...

totcell = scalar (0)
docell
 |
 if ( %.catgrd% ge 0 )
 begin
 totcell = totcell + 1
 end
 |
end

/* convert scalar to variables and prefix with a 'v'
 stoitcell = scalar (totcell )
&sv vtotcell = [show stotcell]
stotarea = scalar (totcell * %celldim% * %celldim% / 10000 )
&sv .vtotarea = [show stotarea]

&if %runopt% eq t or %runopt% eq T &then
    /* write out:catchment no, contour interval, Tot Area, Tot No cells,
       Zmin, Zmax, Relief */
    &sv recrd = [quote %.cnum% %.ci% %.vtotarea% %vtotcell% %GRD$ZMIN% %GRD$ZMAX% %dz% 0 0]
    &if [write %file_unit% %recrd%] = 0 &then
        &do
            &ty record written to %outfil%
        &end
    &else
        &ty EMERGENCY! file not written ... &do
            &sv recrd = ' '
            &if [write %file_unit% %recrd%] = 0 &then
                &do
                    &ty Blank Separator record ...
                &end
            &else
                &ty EMERGENCY! file not written ...
            &end
    &end

/*********************************************************************/
/* Iterate through the contour ranges and count matching cells off
/* the grid ... */

&sv .cum_belt = 0
&sv .cum_vol = 0
&sv .totcumbelt = 0
&sv .avg_tot_slp = 0
&sv n_intvl = 0

&do xxx = %cntr1% &to %cntrn% &by %.ci%
    &sv yyy = %xxx% + %.ci%
&if %xxx% lt %GRD$ZMIN% &then
    &sv .xxxtmp = %GRD$ZMIN%
&else &if %xxx% gt %GRD$ZMAX% &then
    &sv .xxxtmp = %GRD$ZMAX%
&else
    &sv .xxxtmp = %xxx%
&if %yyy% gt %GRD$ZMAX% &then
    &sv yyyymp = %GRD$ZMAX%
&else
    &sv yyyymp = %yyy%
&ty Processing area: %.cnum% %.xxxtmp% to %yyytmp% of %.zmin% to %.zmax%

mape %.catgrd%
setcell %.catgrd%
setwindow %catgrd%

    p1 = scalar(0.0)
cumslp = scalar(0.0)
ncells = scalar(0.0)
ciscrl = scalar( %.ci% )

docell{
    if ( %.catgrd% ge %.xxxtmp% and %.catgrd% lt %yyytmp%)
        begin
    p1 = p1 + %.catgrd%
}
cumsip += %slpgrd%
n_cells = n_cells + 1
end

docell

/* Extract required stats from the accumulations ...
/* convert scalar to variables and prefix with a 'v'

&sv n_intvl = %n_intvl% + 1
&sv v1 = [show p1]
&sv vncells = [show ncells]
&sv .range = [ calc %yytmp% - %. xxxtmp%]

&if ( %vncells% le 0 ) &then
&do
  avg_elev = scalar( (%. xxxtmp% + %yytmp%) / 2 )
  avg_slp = scalar( 0 )
  avg_belt = scalar( 0 )
  sarea = scalar( 0 )
&end
&else
&do
  avg_elev = scalar( p1 / n_cells )
  avg_slp = scalar( cumsip / n_cells )
  avg_belt = scalar( %.range% / [tan [angrad [show avg_slp]]] )
  &sv area_m2 = [calc %vncells% * ( %celldim% * %celldim% )]
&end

&sv vavg_slp = [show avg_slp]
&ty Avg_slp = %vavg_slp%

/* next bit is an accumulation and is averaged after the loop
&sv .avg_tot_slp = %.avg_tot_slp% + %vavg_slp%
&sv vavg_belt = [show avg_belt]
&sv .cum_belt = %.cum_belt% + %vavg_belt%

&sv vavg_elev = [show avg_elev]
&sv area = [show sarea]
&sv cumarea = %cumarea% + %area%
&sv invcumarea = %.vtotarea% - %cumarea% + %area%

&if %.vtotarea% gt 0 &then
  &sv nmlarea = %invcumarea% / %.vtotarea%
&else
  &sv nmlarea = 0
&sv nmlxxx = ( %.xxxtmp% - %GRD$ZMIN% ) / %dz%
&sv nmlyyy = ( %yytmp% - %GRD$ZMIN% ) / %dz%
&sv nmlrange = [calc %nmlyyy% - %nmlxxx%]

/* write out : LOWER cntr (/elev), normalised LOWER cntr (/elev),
/* avge elevation, No. cells, Area (Ha.), Cum. Area (Ha),
/* Actual Inv. Cum. Area, Normalised Inv. Cum. Area,
/* Range, Normalised range

&sv recrd = [quote %. xxxtmp% %nmlxxx% %vavg_elev% %vncells% %area% %cumarea%
  %invcumarea% %nmlarea% %.range% %nmlrange% %vavg_belt% %.cum_belt% %vavg_slp% ]

&if [write %file_unit% %recrd%] = 0 &then
  &sv errcode = 0
&else
  &ty EMERGENCY ! file not written ...

&end /* &do end
&sv .avg_tot_slp = %.avg_tot_slp% / [ calc %.n_intvl% - 1 ]
&ty %.avg_tot_slp%

setwindow cat%.cnum%

&r %PROG_DIR%/adddtab2v0

&sv .nplt = [ calc %.nplt% + 1 ]
&r %PROG_DIR%/gtab3v1

&if %.nplt% eq %.nperpage% &then
  &do
  &sv .nplt = 0
  &sv .npage = %.npage% + 1
  &end

/* allow for unplotted unfinished page of multiple plots
&if %.nplt% gt 0 &then
  &do
    &sv .end = .TRUE.
    &r %PROG_DIR%/gtab3v1
  &end

/* End of processing so close files and 'UNIX2DOS' it ready for /*Excel/Lotus ...
&if %runopt% eq t &then
  &do
    &if [close %file_unit% ] = 0 &then
      &do
        &ty Output file closed
        &ty Converting %outfil% to DOS ...
        &sys mv %outfil% htmp
        &sys unix2dos htmp %outfil%
      &end
    &else
      &ty EMERGENCY ! file not closed ...
    &end

&messages &on
&work %WORK_DIR%

&return
Appendix 2.2

------------------------------------------------------------------------------------------------------------------
/* ADDTAB2v0.aml */
------------------------------------------------------------------------------------------------------------------
/* variables read in from hmetric3v0:
/* base contour
/* Normalised Elevation
/* Average Elevation
/* No. of cells
/* Area in Ha
/* Cum Area in Ha
/* Act. Inv. Cum Area
/* Normalised Inv. Cum Area
/* Range (=ci except at extremities)
/* Avg contour-belt width for true mean slope curve */

&sv.inptab := %.outf%.tbl
&sv.outinf := %.outf%.tab
&sv.cum_vol = 0

arc tables
&if [exists %.outinf% -INFO] &then &do
   sel %.outinf%
   erase %.outinf%
y &end

define %.outinf%
base_ctr
  8
  8
  N
  2
nml_elev
  8
  8
  N
  4
avg_elev
  8
  8
  N
  2
n_cells
  10
  10
i
area_ha
  10
  10
  N
  1
cum_area
  12
  12
  N
  1
inv_cum_area
  12
  12
  N
  1
nml_inv_c_a
  8
  8
&label loop

&if %:x0.aml$next% ne .FALSE. &then
 &do
 &sv count = %count% + 1
 &sv backcount = %backcount% - 1
 &end

&if %count% ne 1 &then
 &do
 cursor x0 next
 &if %backcount% gt 0 &then cursor x3 %backcount%
 &end

&if %:x0.aml$next% eq .true. &then
 &do
 cursor x1 next
 &ty %backcount% %x3.cum_belt%
 &sv :x0.invcumbelt = %.totcumbelt% - %:x0.cum_belt%
 &sv :x0.avgarea = [calc [calc %:x0.inv_cum_area% + %:x1.inv_cum_area% ] / 2. ]
 &sv :x0.nml_avg_a = [calc [calc %:x0.nml_inv_c_a% + %:x1.nml_inv_c_a% ] / 2. ]
 &sv .integral = %:integral% + [calc %:x0.nml_avg_a% * %:x0.nmlrange% ]
 &sv :x0.integral = %.integral%
/* in next bit avgarea(ha) * 10000 to m2 / 1000 to ooo's m2 i.e. * 10
 &sv .cum_vol = %:cum_vol% + [calc %:x0.avgarea% * 10 * ~
 %:x0.range% ]
 &end
 &else
 &do
 /* &sv :x0.invcumbelt = 0
 &ty %backcount% %x0.cum_belt%
 &sv :x0.invcumbelt = %.totcumbelt% - %:x0.cum_belt%
 &sv :x0.avgarea = [calc [calc %:x0.inv_cum_area% + 0. ] / 2. ]
 &sv :x0.nml_avg_a = [calc [calc %:x0.nml_inv_c_a% + 0. ] / 2. ]
 &sv .integral = %:integral% + [calc %:x0.nml_avg_a% * ~
 %:x0.nmlrange% ]
 &sv :x0.integral = %.integral%
/* in next bit avgarea(ha) * 10000 to m2 / 1000 to ooo's m2 i.e. * 10
 &sv :cum_vol = %:cum_vol% + [calc %:x0.avgarea% * 10 * ~
 %:x0.range% ]
 &end
 &goto loop
 &end /* do while
 cursor x0 close
cursor x1 close
cursor x3 close

cursor x0 remove
cursor x1 remove
cursor x3 remove
&return
Appendix 2.3

/* GTAB3v1.aml

VRTAB3v1.aml

/* written ... tid CSIRO, Land and Water
/* modified ... 29.04.97 ... tid - created 2v1 from 2v0
/* ... added capability for 3 plots to a page
/* modified .. 17.06.97 ... tid - created 3v1 from ~/catch/3v0
/* ... mods to fit CHS catchments
/*

/* set variables
    &sv rundate = [ date -tag ]
    &sv outfil = gtab%.npage%%rundate%

units page
textset font
textsymbol 14
textquality proportional
textsize 10 pt
textstyle typeset

/* check global variables have been passed OK
&tty GTAB3v1: .nperpage %.nperpage% and .nplt %.nplt%

&if %.end% eq .FALSE. &then
    &do
        &if %.nperpage% eq 1 &then
            &do
                display 1040
                %outfil%.gra
            &end
            &sv glimx0 = 6.0
            &sv glimx1 = 16.0
            &sv glimy0 = 16.5
            &sv glimy1 = 26.5
            &end

&else &if %.nperpage% eq 4 &then
    &do
        &sv gxcen = 5
        &sv g2xcen = 13.5
        &sv g_dy = 3.5
        &sv mxcen = 17.75
        &sv m_dy = 4

        &if %.nplt% eq 1 &then
            &do
                display 1040
                %outfil%.gra
                &sv glimx0 = %gxcen% - [calc %g_dy% / 2 ]
                &sv glimx1 = %gxcen% + [calc %g_dy% / 2 ]
                &sv g2limx0 = %g2xcen% - [calc %g_dy% / 2 ]
                &sv g2limx1 = %g2xcen% + [calc %g_dy% / 2 ]
                &sv gycen = 25.5
                &sv glimy0 = %gycen% - [calc %g_dy% / 2 ]
                &sv glimy1 = %gycen% + [calc %g_dy% / 2 ]
            &end
    &end
*/maplimits
&sv mlimx0 = %mxcen% - [calc %m_dy% / 2 ]
&sv mlimx1 = %mxcen% + [calc %m_dy% / 2 ]
&sv mlimy0 = %gycen% - [calc %m_dy% / 2 ]
&sv mlimy1 = %gycen% + [calc %m_dy% / 2 ]
&end

&if %nplt% eq 2 &then
&do
&sv glimx0 = %gxcen% - [calc %g_dy% / 2 ]
&sv glimx1 = %gxcen% + [calc %g_dy% / 2 ]
&sv g2limx0 = %g2xcen% - [calc %g_dy% / 2 ]
&sv g2limx1 = %g2xcen% + [calc %g_dy% / 2 ]
&sv gycen = 18.5
&sv glimy0 = %gycen% - [calc %g_dy% / 2 ]
&sv glimy1 = %gycen% + [calc %g_dy% / 2 ]
/*maplimits
&sv mlimx0 = %mxcen% - [calc %m_dy% / 2 ]
&sv mlimx1 = %mxcen% + [calc %m_dy% / 2 ]
&sv mlimy0 = %gycen% - [calc %m_dy% / 2 ]
&sv mlimy1 = %gycen% + [calc %m_dy% / 2 ]
&end

&if %nplt% eq 3 &then
&do
&sv glimx0 = %gxcen% - [calc %g_dy% / 2 ]
&sv glimx1 = %gxcen% + [calc %g_dy% / 2 ]
&sv g2limx0 = %g2xcen% - [calc %g_dy% / 2 ]
&sv g2limx1 = %g2xcen% + [calc %g_dy% / 2 ]
&sv gycen = 11.5
&sv glimy0 = %gycen% - [calc %g_dy% / 2 ]
&sv glimy1 = %gycen% + [calc %g_dy% / 2 ]
/*maplimits
&sv mlimx0 = %mxcen% - [calc %m_dy% / 2 ]
&sv mlimx1 = %mxcen% + [calc %m_dy% / 2 ]
&sv mlimy0 = %gycen% - [calc %m_dy% / 2 ]
&sv mlimy1 = %gycen% + [calc %m_dy% / 2 ]
&end

&if %nplt% eq 4 &then
&do
&sv glimx0 = %gxcen% - [calc %g_dy% / 2 ]
&sv glimx1 = %gxcen% + [calc %g_dy% / 2 ]
&sv g2limx0 = %g2xcen% - [calc %g_dy% / 2 ]
&sv g2limx1 = %g2xcen% + [calc %g_dy% / 2 ]
&sv gycen = 4.5
&sv glimy0 = %gycen% - [calc %g_dy% / 2 ]
&sv glimy1 = %gycen% + [calc %g_dy% / 2 ]
/*maplimits
&sv mlimx0 = %mxcen% - [calc %m_dy% / 2 ]
&sv mlimx1 = %mxcen% + [calc %m_dy% / 2 ]
&sv mlimy0 = %gycen% - [calc %m_dy% / 2 ]
&sv mlimy1 = %gycen% + [calc %m_dy% / 2 ]
&end
&end

&sv inptab := %.outinf%

textcolor black
/* &sv title1 := [quote Catchment %.cnum% ]
&sv title1 := [quote Catchment %.cnum% ]
clipgraphextent on
pageunits cm
pagesize 21 29.7
/* GRAPH 1 :

graphextent 0.0 0.0 1.0 1.0
&sv dxtext = 0.5  
&sv dytext = .5

move [calc %glimx1% + %dxtext% ] [calc %glimy1% - 2 * %dytext% ]  
&sv labpos = [search %.avg_tot_slp% ]  
&if %labpos% gt 0 &then  
&sv labsub = [substr %.avg_tot_slp% 1 [calc %labpos% + 2 ] ]  
&else  
&sv labsub = %.avg_tot_slp%  
&sv lab1 = [ quote Avg Slope = %labsub% ]  
text %lab1% ll

move [calc %glimx1% + %dxtext% ] [calc %glimy1% - 1 * %dytext% ]  
&sv labpos = [search %.integral% ]  
&if %labpos% gt 0 &then  
&sv labsub = [substr %.integral% 1 [calc %labpos% + 3 ] ]  
&else  
&sv labsub = %.integral%  
&sv lab1 = [ quote Integral = %labsub% ]  
text %lab1% ll

move [calc %glimx1% + %dxtext% ] [calc %glimy1% - 3 * %dytext% ]  
&sv labpos = [search %.cum_vol% ]  
&if %labpos% gt 0 &then  
&sv labsub = [substr %.cum_vol% 1 [calc %labpos% - 1 ] ]  
&else  
&sv labsub = %.cum_vol%  
&sv labm = 'm!SUP;3!BAK;*10!SUP;3!BAK; ='  
&sv lab1 = [ quote [unquote %labm%] %labsub% ]  
text %lab1% ll

move [calc %glimx1% + %dxtext% ] [calc %glimy1% - 4 * %dytext% ]  
&sv labpos = [search %.zmin% ]  
&if %labpos% gt 0 &then  
&sv labsub = [substr %.zmin% 1 [calc %labpos% + 1 ] ]  
&else  
&sv labsub = %.zmin%  
&sv lab1 = [ quote Min Elev. = %labsub% ]  
text %lab1% ll

move [calc %glimx1% + %dxtext% ] [calc %glimy1% - 5 * %dytext% ]  
&sv labpos = [search %.zmax% ]  
&if %labpos% gt 0 &then  
&sv labsub = [substr %.zmax% 1 [calc %labpos% + 1 ] ]  
&else  
&sv labsub = %.zmax%  
&sv lab1 = [ quote Max Elev. = %labsub% ]  
text %lab1% ll

move [calc %glimx1% + %dxtext% ] [calc %glimy1% - 6 * %dytext% ]  
&sv labpos = [search %.vtotarea% ]  
&if %labpos% gt 0 &then  
&sv labsub = [substr %.vtotarea% 1 [calc %labpos% + 1 ] ]  
&else  
&sv labsub = %.vtotarea%  
&sv lab1 = [ quote Area (ha) = %labsub% ]  
text %lab1% ll

move [calc %glimx1% + %dxtext% ] [calc %glimy1% - 7 * %dytext% ]  
&sv labpos = [search %.ci% ]  
&if %labpos% gt 0 &then  
&sv labsub = [substr %.ci% 1 [calc %labpos% + 1 ] ]  
&else  
&sv labsub = %.ci%  
&sv lab1 = [ quote Cntr Int. = %labsub% ]  
text %lab1% ll
/* THE LOCATION MAP */

/* &if [exists %.catgrd%c%.ci% -arc] &then kill %.catgrd%c%.ci% all */
arc latticecontour %.catgrd% %.catgrd%c%.ci% 10
maplimits %mlimx0% %mlimy0% %mlimx1% %mlimy1%
mapposition cen cen
units map
mapunits meters
mape %.catgrd%
mapscale auto
shadeset rainbow
&describe dem%.cnum%
mape dem%.cnum%
setwindow dem%.cnum%

&if [exists tmpmsk -grid] &then kill tmpmsk all
tmpmsk = con ( %.catgrd% ge 0, 258 )
&if [exists tmppol -cover] &then kill tmppol all
tmppol = gridpoly ( tmpmsk )
kill tmpmsk all

shadecolor black
shadeput 258
polygonshades tmppol 258
kill tmppol all

describe dem%.cnum%
setwindow dem%.cnum%

&if [exists tmpmsk -grid] &then kill tmpmsk all
tmpmsk = con ( %.catgrd% ge 0, 258 )
&if [exists tmppol -cover] &then kill tmppol all
tmppol = gridpoly ( tmpmsk )
kill tmpmsk all

linecolor black
pensize .015
/* arcs %.catgrd%c%.ci% */
/* kill %.catgrd%c%.ci% all */
pensize .015
linesize .015
linecolor ‘dim gray’
/* &if [exists %work_dir%/c%.cnum%/bnd%.cnum%tm -cover] &then */
/* arcs %work_dir%/c%.cnum%/bnd%.cnum%tm */
&if [exists bnd%.cnum% -cover] &then
arcs bnd%.cnum%
linecolor ‘light gray’
/* &if [exists %work_dir%/c%.cnum%/str%.cnum%tm -cover] &then */
/* arcs %work_dir%/c%.cnum%/str%.cnum%tm */
&if [exists str%.cnum% -cover] &then
arcs str%.cnum%
linecolor black
box %GRD$XMIN%, %GRD$YMIN%, %GRD$XMAX%, %GRD$YMAX%
units page

*/,*/
/* Section to confirm correctness, Convert and Spool to Printer */
/,*/

/* END OF GTAB3v0 ROUTINE ... LOOKING FOR NEXT DATA ! */

/* END OF GTAB3v0 ROUTINE ... LOOKING FOR NEXT DATA ! */
&if %nperpage% eq 1 or %nplt% eq 4 or %.end% eq .true. &then &do
    &sv timestmp = [ date -full ]
    move 171 .
    textsymbol 2
textsize 8 pt
textcolor gray
text %timestmp%
    display 9999
    plot %outfil%.gra
/* &sv plot? = [response 'Create a postscript file for printing? [n] n]
/* ///////////// - this bit thardwired to save having to be at the printer ... 
&sv plot? = y
/*\\\\\\\\
&label reask
&if %plot?% eq y or %plot?% eq Y &then &do
/* &sv outnam = [response 'Name for Output PS file gtab.ps' gtab.ps]
&sv outnam = %outfil%.ps
&if [exists %outnam%] &then &do
&sv del [response 'File already exists, overwrite? [n] n]
&if %del% eq y &then &do
&ty [delete %outnam%]
&else &do
&goto reask
&end
&end
&ty 'Creating ' %outnam%
&sys arc postscript %outfil%.gra %outnam%
/* &sv printnow = [response 'Print now? [n] n]
&sv printnow = y
&if %printnow% eq y or %printnow% eq Y &then &do
&sys lpr -s -Pecops %outnam%
&sys lpq -Pecops
&end &end /* if plot? = yes
/* reset page setup to original
/* display 9999
/* mapscale auto
/* pagesize device
&end
&return