6.0 Discussion

The simulations have indicated regions likely to suffer significant erosion, and these have compared favourably with observations of actual gully formation. The development of a gully has been characterised by significant movement of material onto the lower sections whilst maximum depths range between 1.0m and 1.8m for upper sections.

The location of the gully in model simulations is dependent on the development process dictated by which erosion modules were implemented. Gully formation typically reaches between Row H and Row I in almost all approximations.

The depth of erosion is typically 40 to 70cm, ranging along the observed active sections of Row E through to Row G, whereas the depth of gully in upper section Row A to Row D ranges between 1 to 2m. These details are best described schematically, such as in Figure 6.1, Figure 6.2, and Figure 6.3, and Figure 6.4, with erosion depths with differences between simulations on an event by event basis.

Although the model simulations will over-predict the maximum depth of erosion at the top of the batter slope, the upper section activity seems reasonably estimated with overall depth ranging between 50 to 70cm, in Figure 6.2. Incision at this transition point initially and consequent development down the hillslope and back into the catchment are comparable to standard profile observed in Figure 6.1, as expected. The difference in elevations devised between each storm event was estimated by subtracting the upper surface from the newly eroded surface and the volume approximated.

Table 6.1: Volumetric approximation of overall elevation change between consequent storm events. These estimates were conducted for both final simulation scenarios used in Section 5.5, and Section 5.6. Erosion is represented by negative values, whilst deposition is represented by positive values. These calculations appear in Appendix C.

Surface Profile	Randomised, armouring, wide inlet point, with $n_1 = 2.1$.			Randomised erodibility, armouring, and wide inlet point with $n_1 = 0.69$.		
	261296	010197	230197	261296	010197	230197
batter slope	-6.04 m^3	-5.17 m^3	-9.42 m^3	+25.73 m^3	+2.93 m^3	-1.59 m^3
extended profile	+0.58 m^3	-1.04 m^3	-9.04 m^3	-1.11 m^3	-1.28 m^3	-5.07 m^3
experimental	-46.74 m^3	+1.68 m^3	+5.51 m^3			

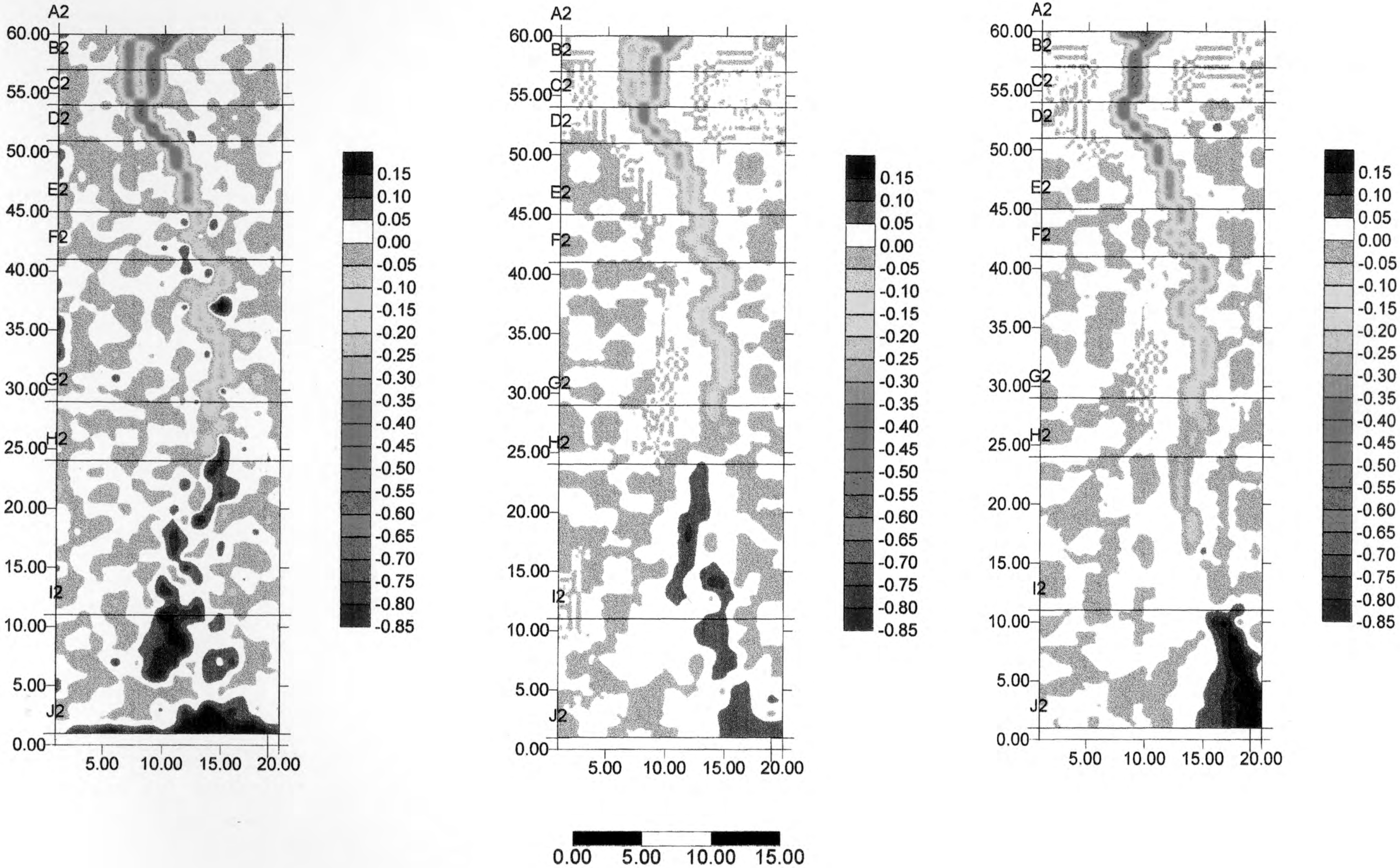

Figure 6.1: The change in elevation from the initial surface is represented by erosion negative, and deposition positive. These simulations are evaluated on a per storm event basis, and include all of the erosion modules as discussed in Section 5.5.

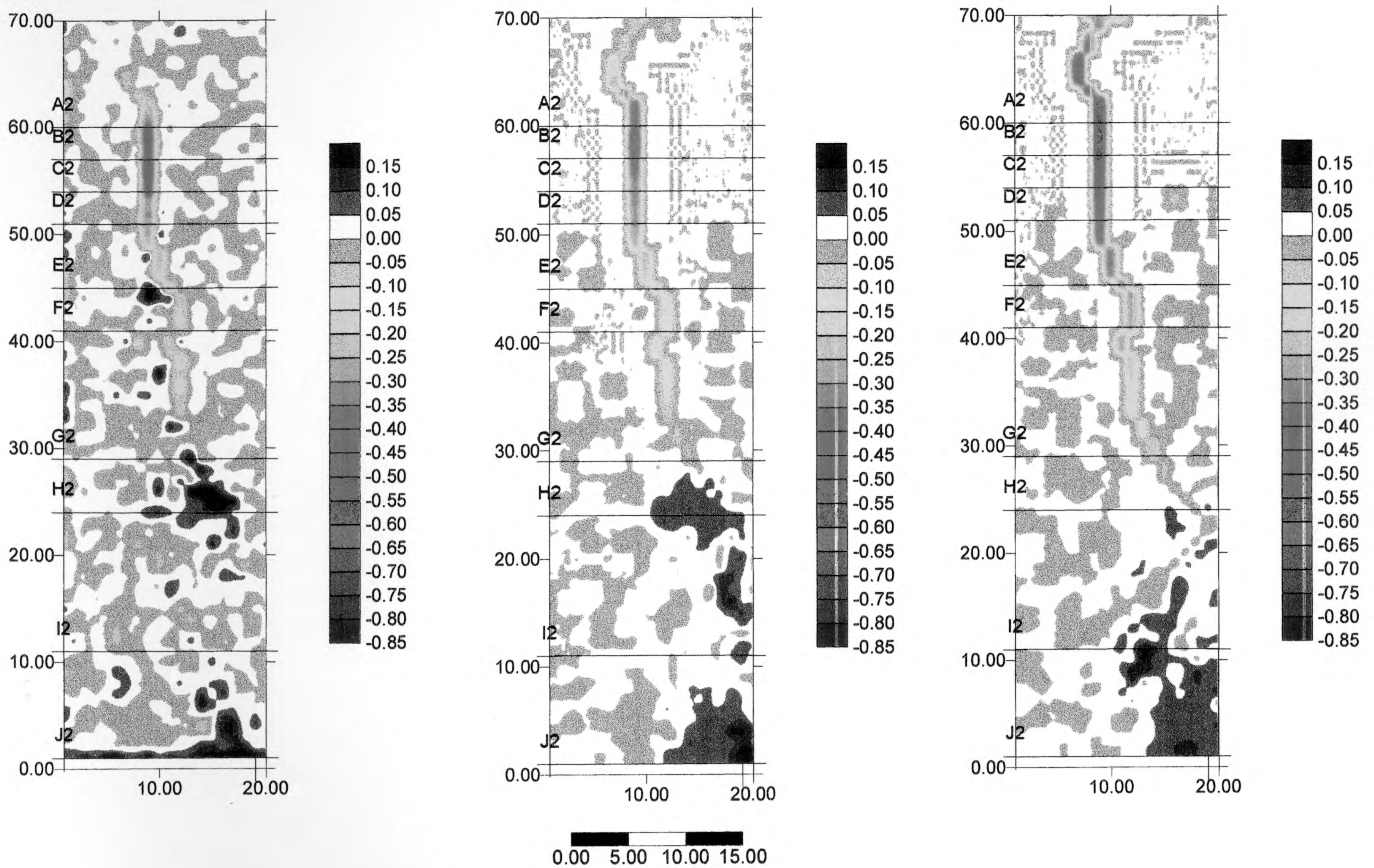

Figure 6.2: The change in elevation between each consequent storm event, is highlighted in this figure, with simulations devised using the erosion modules outlined in Section 5.5. This scenario represents the extended batter slope profile.

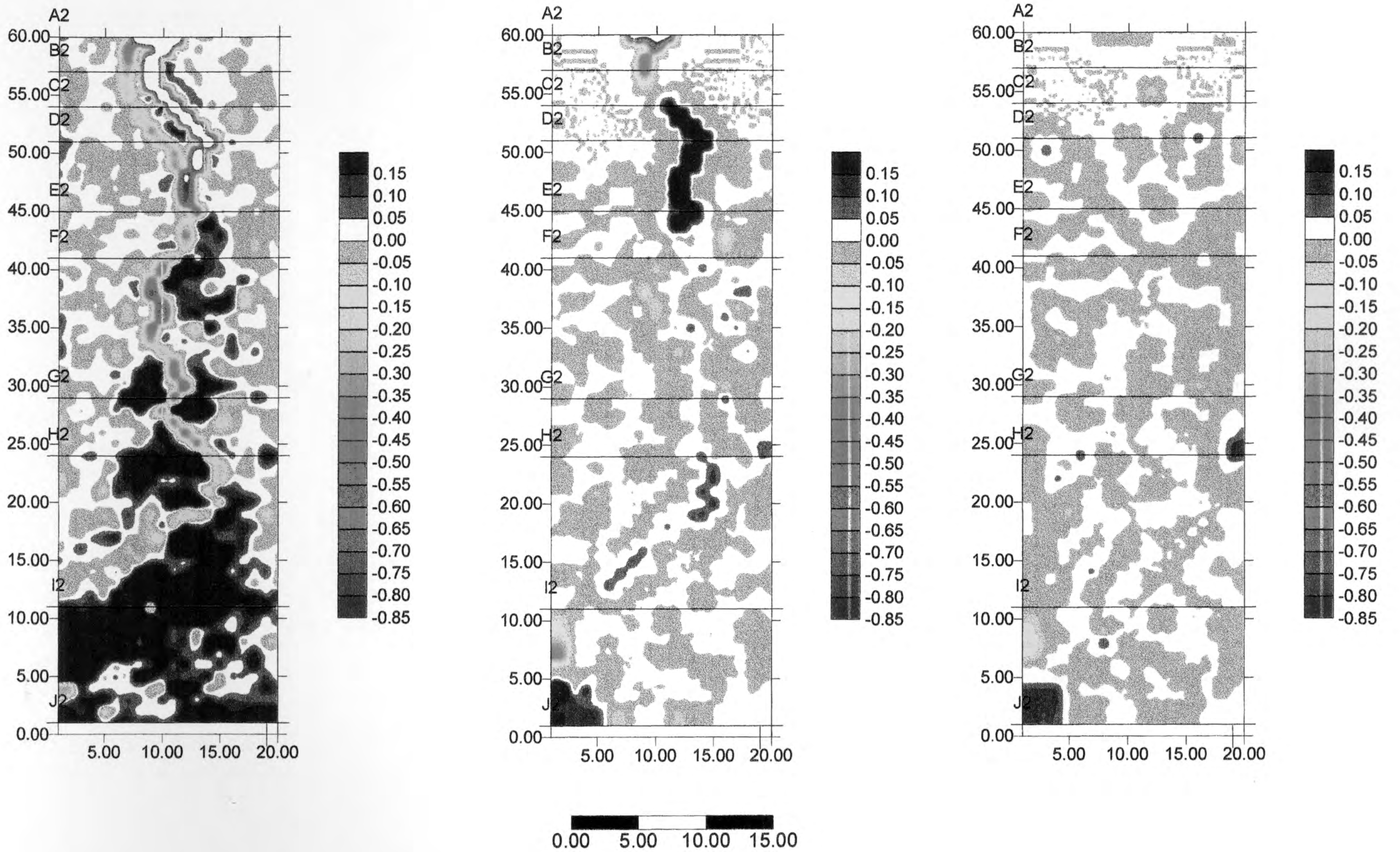

Figure 6.3: The change in elevation between consequent storm events, was evaluated using the simulations from Section 5.6, where this slope is representative of standard batter slope profile.

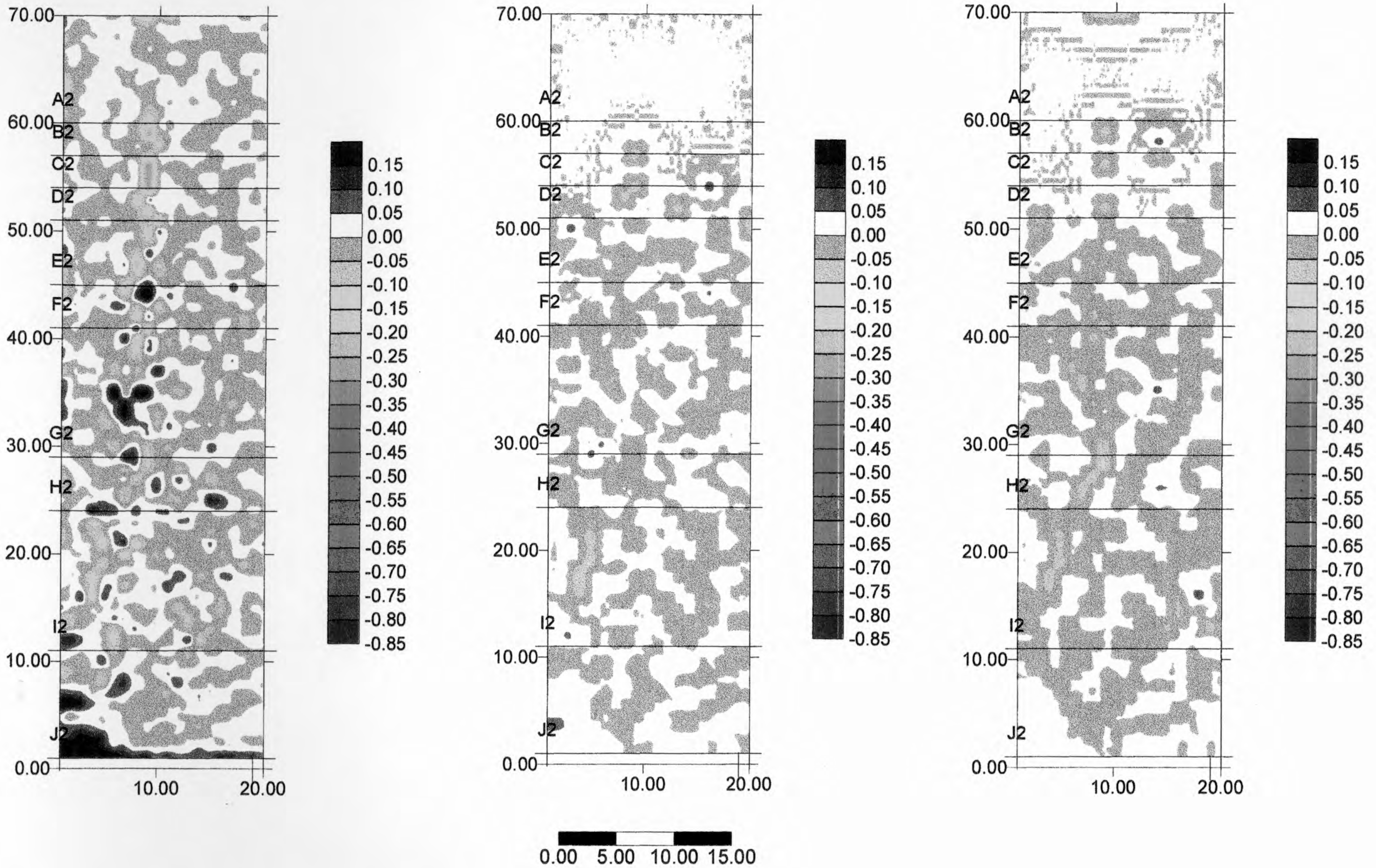

Figure 6.4: The change in elevations between each of the three storm events, are simulated using results from Section 5.6, where the exponent on the slope term in the sediment transport equation is reset to fitted value of 0.69 instead of 2.1.

The comparison of erosional values between experimental results from field trial and model simulations from the two final model scenarios indicate a similar overall result, although development of the gully is considerably different. Given the inherent variability in the surface material and the large scale of the field site, a reasonable comparison between these figures was expected., although the development process in the model simulations was more sequential.

Willgoose and Loch, 1996 notes that the behaviour of the incising erosion model can be quantified by the parameter, α.

$$\alpha = \frac{m_1 m_3 - 1}{n_1} \qquad (6.0.1)$$

where

m_1, m_3 = physical parameter exponents in the sediment transport model.

For the erosion studies previous conducted parameter values obtained of m_1, n_1 and m_3 of 1.68, 0.69 and 0.9 equated to an α of 0.65. These adapted results were used in this study with m_3 taken to be 1, and m_1 = 1.68, whilst the slope parameter n_1 was examined using two cases n_1 = 0.69, and n_1 = 2.1, with model simulations in Section 5.5 having equivalent value of alpha at 0.32 (n_1 = 2.1).

The rate of incision is highly dependent on the armouring of the WRD site, with large boulders exposed in the upper sections of the gully were of significant size, with other considerations such as the with of the formation dependent on the nature of the inlet point.

The sensitivity of the model to parameter choice for $n_1$seems critical, although once the fully developed armouring module is enabled the surface in erosion depths observed in Section 5.6, will be abated, leading to a less incising model.

However detailed examination of particle size profile of the site was not conducted during this time, although this will not present insurmountable difficulties as estimates can be made from exposed side walls such as those appearing in Figure 3.2.19.

As discussed, the development of equilibrium profile of the slope was demonstrated by accumulation of fine material at the very top of the slope, resulting in only several centimetres of erosion before large fragments encountered. Also noted was the dynamic nature of waste rock with geochemical weathering observed during the dry season altering the gully formation significantly.

The dynamic equilibrium between and accumulation of material in the channel beds by weathering may establish a layer of material which is constantly changing, averting maximum erosion depths observed on-site, as well as in model simulations lasting for long periods.

Thus in summary, this investigation has demonstrated that gully development on the steep batter slopes can be feasibly represented by model simulations of SIBERIA without the addition of physically based processes to alter the homogenous initial surface, and allow for the armouring that does occur.

Results for non-armoured surface indicated that depths of the order of 4 to 5m at the top of the slope, although these predictions are highly dependent on slope exponent parameter selection with behaviour of gully development representative of that observed on site. Armouring reduces maximum depth of erosion to 1.8m.

The heterogenous, armoured, and increased width inlet scenario represents the optimal calibration of the model at this stage to the study site. Further investigation into the derivation of the value for the slope component n_1 is warranted, as demonstrated above. However all of the model simulations encapsulate the observed development mechanisms, with the development of a more realistic, less conservative estimate of depth-erodibility relationship, increased grid discretisation and further increasing the accuracy of model predictions.

The combination of aspects such as random erodibility, increased catchment outlet width, and rudimentary armouring module has improved estimate of total erosion depth whilst maintaining the dynamical behaviour observed.