ECOLOGICAL IMPACTS OF HIGHVELD GERBILS (*TATERA BRANTSII*) ON A REHABILITATED ASH DISPOSAL SITE

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Thesis submitted to the Department of Zoology (School for Environmental Sciences and Development) at North-West University in partial fulfilment of the requirements for the degree Magister Scientiae (Zoology).

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ABSTRACT

Ecological Impacts of Highveld Gerbils (*Tatera brantsii*) on a Rehabilitated Ash Disposal Site

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Tatera brantsii was numerically dominant in the small mammal community on the plateaux of the rehabilitated ash disposal sites of ESKOM's Hendrina Power Station in 1998 and 1999 (Vermaak 2000). The species seemed well adapted to exploit this environment and, through biopedturbation, had altered the topsoil structure and chemistry. The consequences of this and other activities also affected the rehabilitated plant community of the PFA-dam habitat. Burrowing appeared limited to just under the topsoil layer, and seemed more extensive than burrows of this species in natural ecosystems. The burrow system architecture was mapped and quantified, and localised increases in nitrates, phosphorous and organic carbon in immediately associated substrate were noted. However, this substrate enrichment was transient, and disappeared following the abandonment, and subsequent collapse of burrow systems, when gerbil colonies migrated away from the area. The mixing of soil horizons also resulted in a more homogeneous substrate, which was more friable, and thus drier. The high pH and salinity of the topsoil layer in areas undisturbed by gerbil burrowing, and concentrations of particular elements associated with either the topsoil covering or the ash, were reduced as a consequence of substrate mixing in disturbed areas. Gerbil impacts on the substrate of this habitat seemed to promote pedogenesis, eliminating the sharp distinction between the topsoil covering and the ash below, but the re-exposed ash of the burrow mounds would become subject to erosion, and reduce the effectiveness of the rehabilitation effort. Gerbil activities increased the number of plant species, especially ruderal forbs, comprising the plant community of the PFA-dam habitat, but plant community diversity was not significantly increased. However, numerical dominance by few tussock grass species was diminished, possibly reflecting burial under mounds of excavated substrate. The biomass and cover of some grass species were reduced in areas of gerbil impacts, and plant life-cycles appeared to be completed sooner in areas affected by gerbil activities. These effects may be as a result of the drier substrate produced following the collapse of the extensive network of abandoned burrows. The succession of this plant community towards an underutilised grassland state, the expected outcome of the rehabilitation effort, was minimally affected by gerbil activities. The effects of *T. brantsii* activities in this PFA-dam habitat were not as distinct as the effects noted by other authors studying fossorial rodent impacts in less disturbed habitats. This could be because further disturbances in this habitat would merely add to the currently disturbed state, whereas disturbance in more natural habitats, would show more of a change from the initial state.

Keywords: biopedturbation; burrows; disturbance; fossorial rodents; industrial habitats; PFA-dams; plant succession; rehabilitation; small mammals; soil properties; South Africa

UITTREKSEL

Ekologise Impakte van die Höorveld se Nagmuis (*Tatera brantsii*) op `n Gerehabiliteerde As-stortingsterrein

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Tatera brantsii was numeries dominant in die klein soogdiergemeenskap op die plato's van die gerehehabiliteerde as-stortingsterrein van Eskom se Hendrina kragstasie in 1998 en 1999 (Vermaak 2000). Die spesie blyk goed aangepas te wees om hierdie omgewing te gebruik, en het die bogrond se struktuur en chemie gewysig deur "biopedturbation". Hierdie en ander aktiwiteite het ook die gerehabiliteerde plantgemeenskap van die PFA-dam beïnvloed. Tonnelgrawing blyk beperk te wees tot die area net onder die bogrondlaag, en blyk ook meer ekstensief te wees as hierdie spesie se tonnelwerk in natuurlike ekosisteme. Die tonnelsisteem se argitektuur was gekarteer en gekwantifiseer, en gelokaliseerde vermeerdering van nitrate, fosdor en organise koolstof in direk geassosiëerde substraat was genoteer. Hierdie substraatverryking was egter tydelik en het verdwyn sodra die tonnels verlaat is en gevolglik verval het sodra die nagmuis- kolonies migreer het. Die vermenging van grondhorisonne het 'n meer homogene substraat tot gevolg gehad wat meer krummelrig en dus dröer was. Die höe pH en soutinhoud van die bogrondlaag in areas onverstoord deur nagmuis-grawery en konsentrasies van spesifieke elemente wat óf met die grondlaag bedekking óf met die as geassossieër is, was verminder as gevolg van substraatvermenging in versteurde areas. Dit wou voorkom of die impak van die nagmuis op die substraat van hierdie habitat "pedogenese" bevorder het en die sterk onderskeid tussen grondbedekking en die aslaag daaronder geëlimineer het, maar die blootgestelde as in die tonnelhopies was aan erosie onderhewig, en het die effektiwiteit van die rehabiliteringsaksie verminder. Nagmuis- aktiwiteite het die hoeveelheid plantspesies vermeerder, veral "ruderale" kruie, wat die plantgemeenskap van die PFA-dam habitat behels het, maar die plantgemeenskap se diversiteit was nie merkbaar vermeerder nie. Die numeriese dominansie van 'n paar polgrasspesies is egter verminder, moontlik as gevolg van begrawing onder hope omgedolwe substraat. Die biomassa en dekking van sommige grasspesies was verminder in die gebiede waar nagmuise impak gehad het, en plante se lewenssiklusse blyk vinniger voltooi te word in gebiede wat deur nagmuis-aktiwiteite geraak was. Hierdie gevolge is moontlik as gevolg van die droër substraat wat gevorm is nadat die ekstensiewe netwerk van verlate tonnels ingeval het. Die "suksessie" van hierdie plantgemeenskap na 'n "lae-verbruik" grasveld-staat (toestand) – die verwagte resultaat van die rehabiliteringsprogram – was minimal beïnvloed deur nagmuis- aktiwiteit. Die effek van *T. brantsii* in hierdie PFA-dam habitat was nie so duidelik soos die effek wat ander outeurs tydens die studie van "fossoriële"knaagdier impak in minder versteurde habitats gevind het nie. Dit kon wees omdat die verdere versteuring van hierdie habitat slegs bygedra het tot die reeds versteurde habitat, waar versteuring in 'n meer natuurlike habitat 'n groter onderskeid sou toon met die oorspronklike stand van sake.

Sleutelwoorde: "biopedturbation"; "fossoriële"knaagdier; grond einskappe; industriële habitat; klein soogdiere; PFA-damme; plante-"suksessie"; rehabilitasie; Suid Afrika tonnelwerk; versteuring

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pools could lodge and germinate (Dean & Milton 1991b; Olff & Ritchie 1998), and similarly, the coarser, broken substrate of abandoned zones may have facilitated the germination of seeds.

The dominance by grasses was considerably reduced after gerbils abandoned the area, largely because of the reduced contribution of a single species (*P. clandestinum*). Plant individuals became more evenly spread across species comprising the community as a result of gerbil activities.

Based on the ecological status of grasses in the control zones, these areas were undergoing succession as the community consisted of a greater number of sub-climax increaser II species, with an ecological trajectory towards a potentially underutilised climax state (as indicated by the presence of an increaser I grass). This was the expected outcome following the ecological rehabilitation of the PFA-dam at Hendrina power station (see Section 2.1.6). Gerbil activity (active zones) stimulated an increase in grass species, including a palatable decreaser climax grass, indicating that while still at the sub-climax stage, the community had become more diverse. Following abandonment, the main result of gerbil impact on the ecological status of this plant community variant seemed to be the encouragement of secondary succession as the impact promoted grass species indicative of a pioneer or sub-climax stage (van Oudtshoorn 1991). Transect data showed no change in ecological status from controls after impacts by gerbils had ceased, and quadrate data showed only a slight net gain of increaser II species for the community relative to controls. Overall the ecological status was not changed very much by the activities of gerbils, and secondary succession was only slightly promoted.

In active zones (Fig. 6.2), where gerbil disturbance was current and ongoing, substrate disruptions (namely excavated mounds, scratches, and diggings by gerbils into the crust) probably aided the establishment of new species (Dean & Milton 1991b). These open spaces provide sites where new species of plants from regional species pools can become established without competition from pre-existing plants (Olff & Ritchie 1998), and gerbil burrowing would also disrupt pre-existing root systems, further reducing competition from already established plants (Dean & Milton 1991a).

In impact zones abandoned by gerbils (Fig. 6.2), prior disruption of the topsoil crust by digging and burrowing, followed by the collapse of subterranean tunnels, and subsequent mixing of the substrate resulted in the coarser texture of the substrate (see Section 4.1), which may have been conducive to the establishment of plant species, particularly grasses.

Gerbil activities, either current (active zones) or past (abandoned zones) thus did not significantly change the evenness indices of this plant community variant (Fig. 6.3). The influx of individuals of new species in areas affected by gerbil impact appeared to be too few per species to effect change in the evenness indices. The reduction in dominance of a few species (see Section 6.1) was also not extensive enough to alter the evenness indices of the community.

Despite the increase in the number of species, gerbil activities proved insufficient to significantly alter the overall plant diversity, grass diversity or forb diversity indices from their original values in control zones (Fig. 6.4). This was possibly because individuals of new species introduced to the plant community were too few (low evenness) to affect the species diversity indices.

The biomass of the nut sedge *C. esculentus* was increased by gerbil impacts (Fig. 6.6d), especially where their activities were current (active zones), as this early successional forb species favours areas of disturbed soil, such as those brought about by gerbil burrowing (de Moor 1969). The increased biomass of *T. minuta* seems to be a reflection of the increased dominance of this forb in areas of gerbil impact (see Section 6.1), and it may possibly also indicate that *T. minuta* is less palatable than other forbs promoted by gerbil disturbance (Dean & Milton 1991b), thereby escaping predation by gerbils.

The reduced biomass of the grass *P. clandestinum* in abandoned zones (Fig. 6.6a) reflected the reduction in dominance of this species (see Section 6.1), possibly because the friable substrate of abandoned zones is drier. Increased *S. pinnata* biomass (Fig. 6.6c), after the area was abandoned by gerbils, may indicate the relaxation of grazing pressure, or possibly that *S. pinnata* is more tolerant of drier, coarser substrates, as density of this species was also increased (see Section 6.6).

The percentage of area covered by foliage (crown cover) remained similar among impact zones, whereas the percentage of space between plants (zero cover) increased and the percentage area covered by

plant stems (basal cover) decreased following gerbil activity (Fig. 6.7). Thus gerbil activities opened up the vegetation, creating more space in the grass sward.

The increased amount of space between plants in abandoned zones may be an effect of the drier substrate limiting foliage growth. It could also reflect a change in dominance among species of the plant community (see Section 6.1), where, because of the increased numbers of forb species, plant canopies of species were comparatively smaller. The decreased amount of space between *H. hirta* individuals of active zones (in the zero cover category) may have resulted from the increased dominance of this species in terms of frequency of occurrence (see Section 6.1).

The proportional contribution to plant community crown cover of the grass species *E. curvula* was decreased by gerbil activity, possibly representing the destruction of individuals by burial under excavated substrates, as both dominance and density were reduced in areas of gerbil impact (see Sections 6.1 & 6.6).

A decrease in the percentage of the larger stem-diameter grasses, and the increase in percentage of small diameter forbs could account for the lower basal cover index found. Gerbil activities seemed to promote forb individuals over grasses in this plant community variant (see Section 6.6).

In areas where gerbil activity was current and ongoing (active zones), the increased densities of *C. esculentus* may have been brought about by the disturbance caused by gerbil burrowing, as this species is known to establish well in disrupted substrates (de Moor 1969).

The friable substrate of abandoned zones, resulting from the mixing of soil horizons following tunnel collapse, and the reduced competition from dominant species because of gerbil activities, probably facilitated the establishment of ruderal forbs (annual weeds), which increase following disturbance (Dean & Milton 1991a, b). Each forb species with sufficient numbers of individuals to be sampled in more than one impact zone, reflect this increase in forb density in abandoned zones. This is a complete turnaround from the initial situation in control zones, where the density of grasses was higher. The increase in total density was probably as a result of the increase in forb density (Fig. 6.10).

The greater density of seedlings (Fig. 6.12) observed in abandoned zones may reflect increased seedling establishment in the loose substrates caused by the collapse of gerbil burrow systems (Dean & Milton 1991b), or that seedlings escaped predation by gerbils (unlike seedlings germinating in active zones). The forb *C. biensis* also had increased seedling density in this impact zone. The grass *H. hirta* had a greater density, as well as a higher frequency, of seedlings in zones where gerbils were active, but this could be a reflection of the increased dominance of this plant species (see Section 6.1). Seedling density of *A. glabratum* was diminished in areas of gerbil impact, possibly having been out competed, or their numbers simply diluted by the increased numbers of new species on active and abandoned zones.

Analysis of the samples taken during the middle of the growth season in 1999, indicated that gerbil activities did not significantly alter the overall densities or frequencies of non-flowering mature plants from the control zones (Fig. 6.15). However, the non-flowering mature plant densities of many individual species were changed by gerbil impact. The non-flowering mature plant densities of some common grass species were reduced by gerbil activities, namely: *E. curvula*, *H. hirta*, *P. clandestinum* and possibly also *E. plana*. This was more apparent from abandoned site data than from active zones, and is likely to have been attributable to the increased forb density in abandoned zones (see Section 6.6) making up greater proportions of the samples. The possible burial of tussocks under substrate excavated by gerbil digging would account for the reduction of non-flowering mature *E. curvula*, *H. hirta* and *E. plana* densities on active zones. *P. clandestinum*, being stoloniferous, could be less affected by burial, thus accounting for their higher recorded density here (Fig. 6.16b).

Non-flowering mature densities of *S. pinnata* were reduced by the presence of gerbils (active zones), and this could possibly be attributable to selective feeding as the biomass and overall density of this species were also reduced in active zones (Fig. 6.16e). The disruption of the substrate by gerbils that encouraged increased biomass and species densities of *C. esculentus* (de Moor 1969; see Sections 6.4 & 6.6) seems to be reflected by increased numbers of individuals at this non-flowering mature life-cycle stage.

T. minuta may have contributed a higher proportion of non-flowering mature plants to the overall frequency of non-flowering mature plants in active zones, possibly because it is an unpalatable species.

The increased density of flowering plants (Fig. 6.18) in the middle of the 1999 growth season in

abandoned zones could be as a response to the coarser, and thus drier, substrate of abandoned zones hastening plant life-cycles. Flowering plant frequency seemed higher in active zones, but the variability in the percentage flowering plant data on active zones (mean: 68.7 %, SD: ±59.5 %) obscured any statistically detectable differences with abandoned (mean: 3.3 %, SD: ±1.5 %) or control zones (mean: 9.0 %, SD: ±5.3 %).

The lower flowering *S. pinnata* density in active zones reflects that this species does not tolerate direct gerbil impact, as this species also shows reduced biomass and density. The increased proportional contribution to the frequency of flowering plants by *S. pinnata* in abandoned zones was possibly because of the increased number of individuals established in the abandoned zones (see Section 6.6).

In the middle of the growth season, the overall density of plants with seed (Fig. 6.21) was highest in areas abandoned by gerbils, and the frequency was also slightly elevated on abandoned zones. Perhaps this life-cycle stage was reached sooner by plants in abandoned zones due to the drier substrate. The reduced dominance of *C. biensis* in active zones is reflected here by the decreased density of *C. biensis* with seed, possibly indicating that most *C. biensis* individuals were at this life-cycle stage. Conversely, the increased dominance of *H. hirta* (see Section 6.1) in active zones may be reflected here by the higher proportion of *H. hirta* with seed.

These middle-of-season samples showed higher overall densities of plants with chaff (Fig. 6.24) in abandoned zones, life cycles of plants probably having been accelerated as a response to the drier soil (Section 4.1).In abandoned zones, greater numbers of *S. pinnata* plants were in the chaff stage of their life-cycles, again probably as a result of the drier soil (Fig. 6.25).

Gerbil activities increased the overall densities and percentages of dead plants (Fig. 6.26), more on abandoned zones than on active zones. On active zones, burial under excavated substrate, and the drier substrate on abandoned zones, were the probable causes of this.

The increased numbers of plant individuals, especially forbs, where *T. brantsii* had an impact was one of the principal ways that defined variability in the data, and thus separation of impact zones. The consequences of gerbil activities were more distinguishable from the initial state before the impact, than where impacts were currently being effected.

The areas resulting from gerbil impact (abandoned zones) were distinguished from controls and areas where gerbils were active, particularly by their increased species richness. Increases in both density and species richness probably resulted from the disturbance of the substrate by gerbil diggings, which facilitated the recruitment of plant individuals.

In these mid-season samples, the flowering, seed, chaff and dead stages of plant life-cycles were already significant in abandoned zones, hinting that their drier substrate may be accelerating these life-cycles. Topsoil is mixed in with the ash in abandoned zones, which consequently have more friable substrates (see Section 4.1), and while the recruitment of new species from regional species pools (Dean & Milton 1991b) may be facilitated by the disruptions to the substrate in active zones, it is not as coarse, and thus as dry, as that of abandoned zones.

6.10 Conclusions

In 1999, in the middle of the growth season, *T. brantsii* impacts in the *Lepidium bonariensis-Eragrostis trichophora* plant community variant were apparent, and it was observed that they affected physiognomy, phenology and community parameters. In abandoned zones, cover was reduced, and gerbil impact appeared to have already begun to effect change in the composition and phenology of the plant community. Dominance by a few grass species was reduced and many more species had been introduced into the community. The effects of gerbils in this industrial habitat seemed similar to the effects of small mammals in natural habitats (Korn & Korn 1989; Martinsen *et al.* 1990; Dean & Milton 1991b; Huntly & Reichman 1994; Olff & Ritchie 1998).

The results of this second year survey seem to correlate well with those found in 1998, but this is examined further in the next section.

6.11 Comparison of the *Lepidium bonariensis-Eragrostis trichophora* plant community variant on PFA-dam A of Hendrina Power Station between 1998 and 1999

6.11.1 Diversity, Evenness and Richness

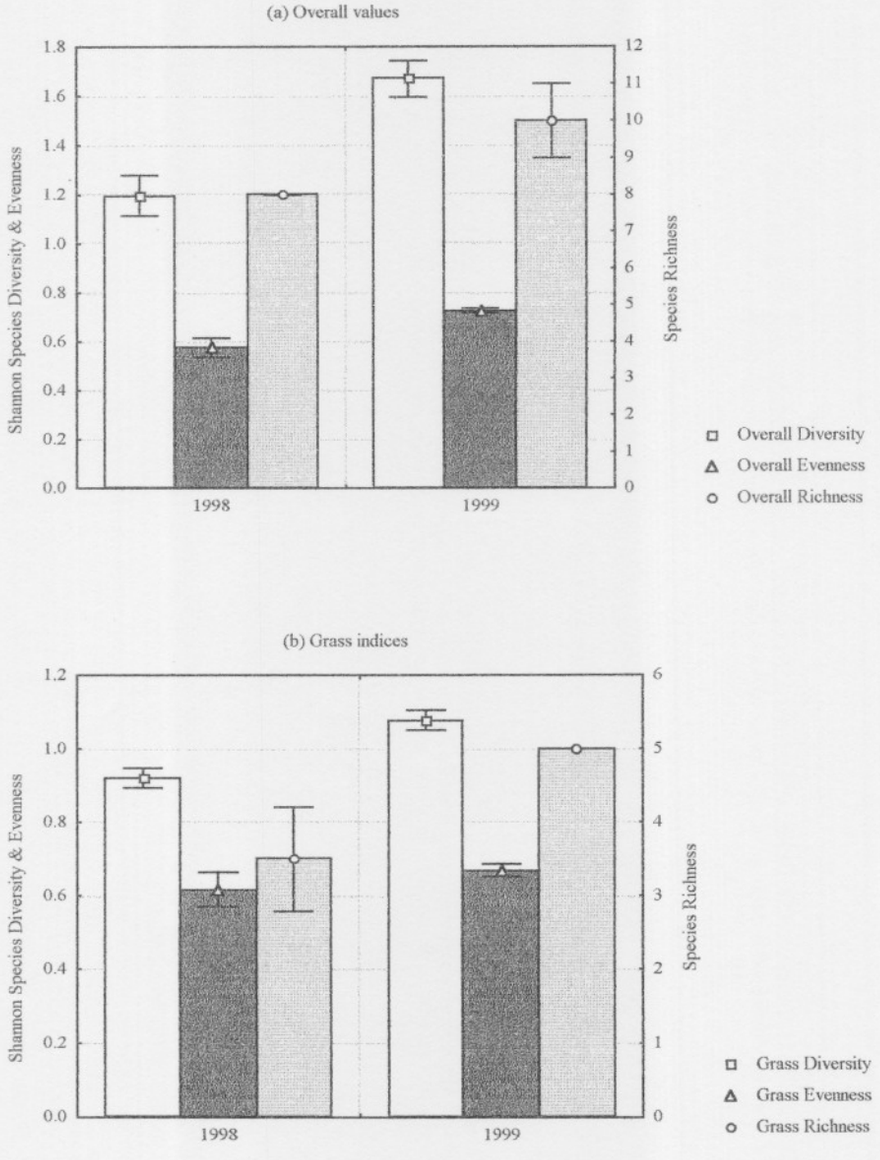

Figure 6.28: Comparative diversity, evenness and richness indices on PFA-dam A from transect samples of control zones between 1998 and 1999. a) overall plant community & b) grasses. Bars denote mean values, vertical lines represent 1SD.

No significant differences in diversity, evenness or richness indices between 1998 and 1999 were noted for the quadrate samples.

The general plant community differed in overall frequency (from transects) of diversity and evenness (Fig. 6.28a), as well as grass species diversity and richness percentages (Fig. 6.28b). The 1998 samples had lower overall diversity (t_{df3}:-6.780, $P < 0.01$, means: 1998: 1.198±0.083; 1999:

1.670±0.073) and evenness indices (t_{df3}:-6.782, $P < 0.01$, means: 1998: 0.576±0.040; 1999: 0.726±0.010). Grass species were more diverse in 1999 (t_{df3}:6.419, $P < 0.01$, means:1998: 0.921±0.027; 1999: 1.079±0.027) and had greater species richness (t_{df3}:4.025, $P < 0.05$, means: 1998: 3.500±0.707; 1999: 5.000±0.000) than the 1998 samples.

6.11.2 Plant density

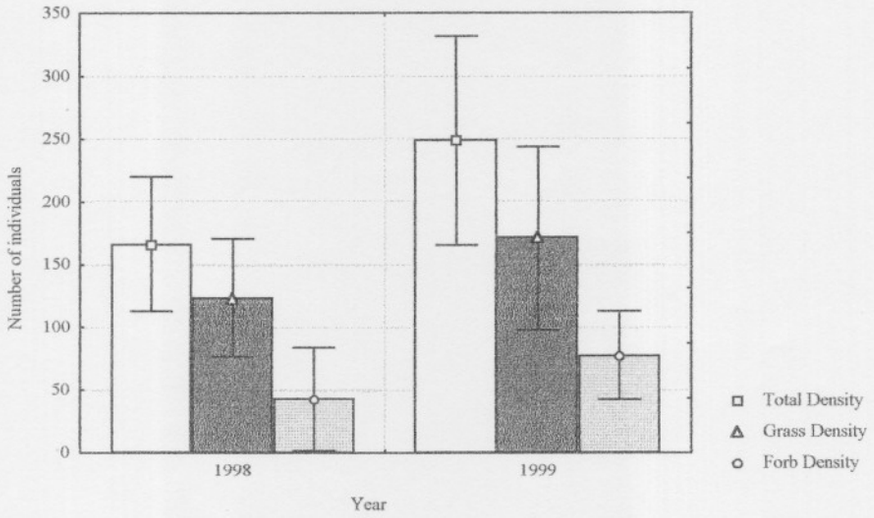

Figure 6.29: Comparative species densities from quadrate samples of control zones of PFA-dam A between 1998 and 1999. Bars denote mean values, vertical lines represent 1SD.

Densities in 1999 (Fig. 6.29), although higher than in 1998, were not significantly different.

6.11.3 Plant biomass

Overall plant biomass (data $\log_e$ transformed, Fig. 6.30) on control zones was reduced in 1998 compared to 1999 (t_{df13}:-5.576, $P < 0.001$, means: 1998: 4.970±0.194; 1999: 5.955±0.398). Grass biomass did not differ between the two years in this plant community variant. Forb biomass was lower in 1998 than in 1999 (t_{df13}:-8.370, $P < 0.001$, means: 1998: 2.415±0.600; 1999: 5.228±0.660).

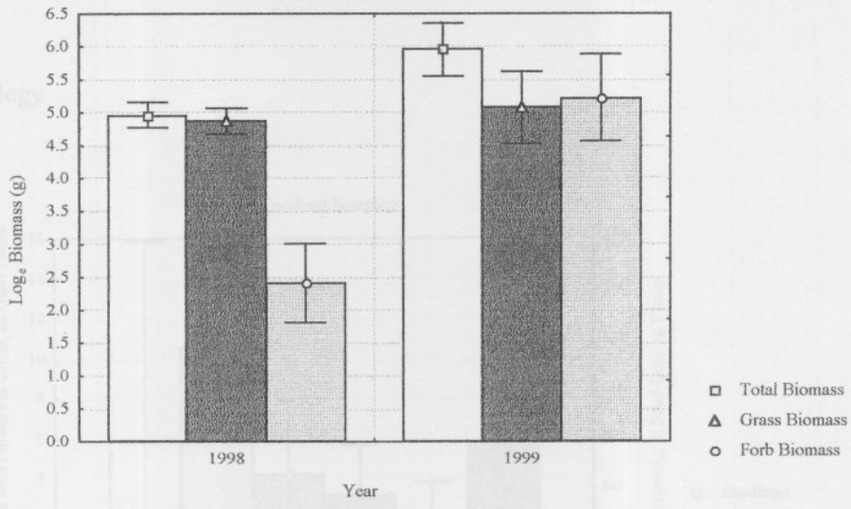

Figure 6.30: Comparative biomass indices from quadrate samples of control zones on PFA-dam A between 1998 and 1999. Bars denote mean values, vertical lines represent 1SD.

6.11.4 Plant canopy cover

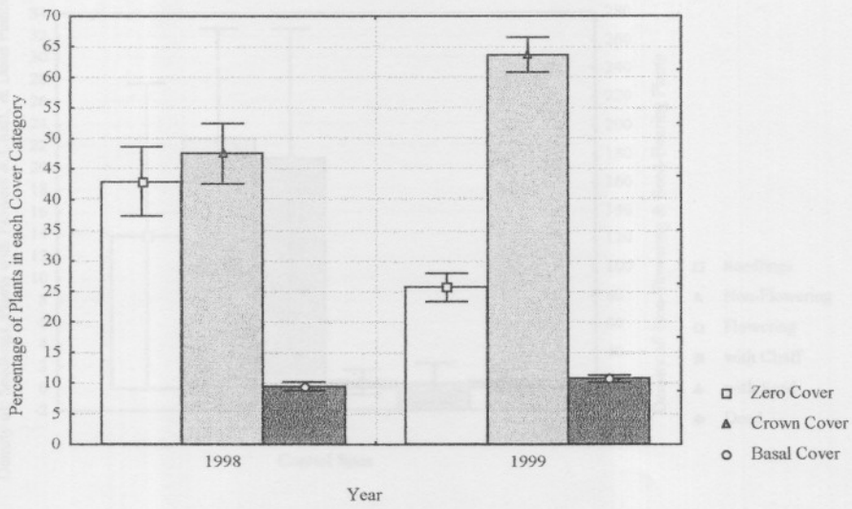

Figure 6.31: The percentages in each of three cover categories (i.e.: Zero; Crown & Basal cover) on PFA-dam A between 1998 and 1999. (From transect data.) Bars denote mean values, vertical lines represent 1SD.

In 1998 there were significantly greater percentages of plants in the zero cover category (t_{df3}:5.035, $P < 0.05$, means: 1998: 43.000±5.657; 1999: 25.667±2.309), and lower percentages in the crown cover category (t_{df3}:-4.781, $P < 0.05$, means: 1998: 47.500±4.950; 1999: 63.667±2.887; Fig. 6.31).

6.11.5 Plant phenology

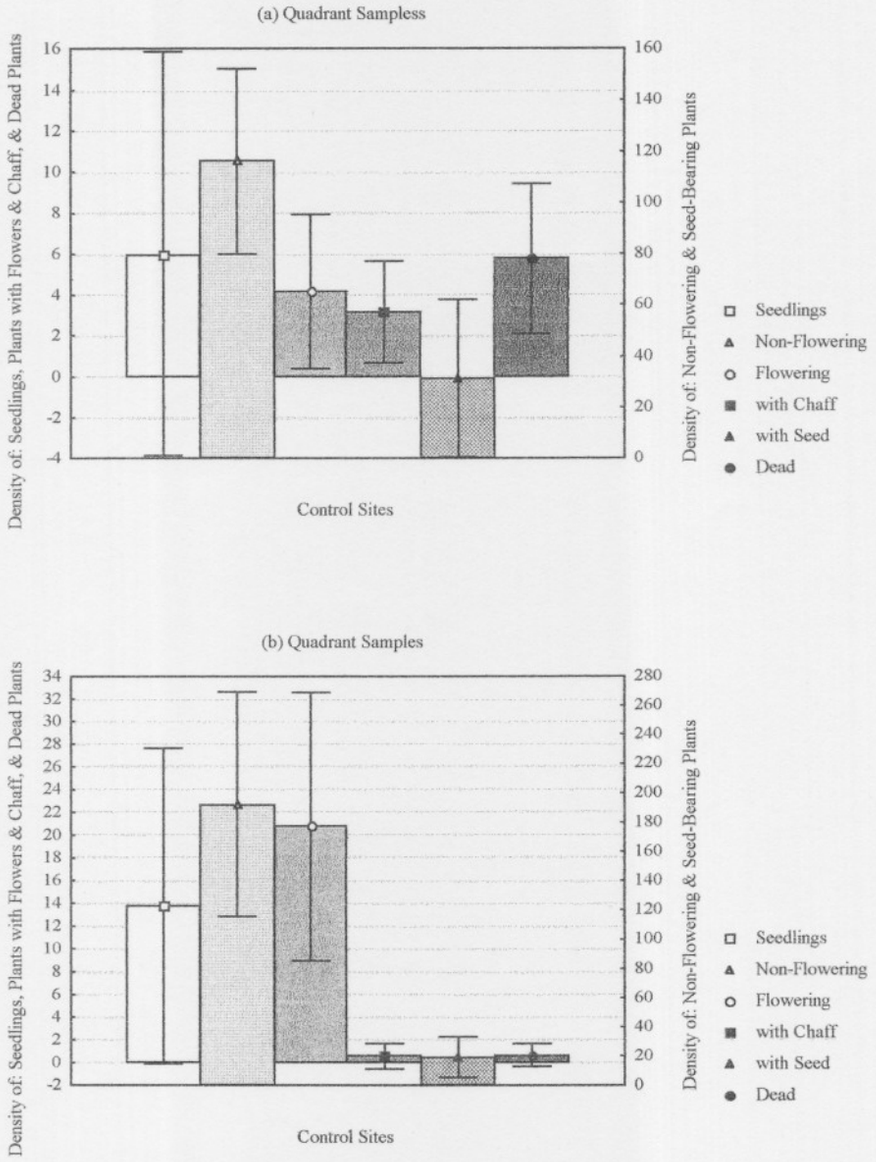

Figure 6.32: Comparative plant phenology from quadrate samples of control zones on PFA-dam A between 1998 and 1999. Bars denote mean values, vertical lines represent 1SD.

Analysis of the phenological state of the plant community variant showed that although the number of seedlings and mature plants bearing seed did not differ significantly between the two years, the other aspects did.

In 1998, a greater proportion of plants sampled were found to exhibit a phenological state characteristic of the latter stages of a plant`s life cycle. There were more plants with chaff (t_{df13}:2.788, $P < 0.05$, means: 1998: 3.167±2.483; 1999: 0.556±1.130) and more dead plants (Z:3.005, $P < 0.01$, means: 1998: 5.750±3.657; 1999: 0.667±1.000) in 1998 (Fig. 6.32a). Conversely in 1999 more plants were at the middle stages of plant life-cycles and 1998 samples showed lower densities of mature non-flowering (t_{df13}:-2.242, $P < 0.05$, means: 1998: 116.250±36.116; 1999: 192.278±76.892) and flowering (t_{df13}:-3.299,

$P < 0.01$, means: 1998: 4.167±3.764; 1999: 20.778±11.809) plants (Fig. 6.32b).

The percentage of dead plants (assessed from transect samples but not illustrated) was also greater in 1998 than in 1999 (t_{df3}:6.197, $P < 0.01$, means: 1998: 3.000±0.000; 1999: 0.333±0.577).

6.11.6 Discussion and Conclusions

The general plant community characteristics were very similar for the two consecutive years (Fig. 6.28). Quadrats had equivalent overall species, grass and forb diversities, the evenness of species was not changed from the previous year and species richness was likewise similar. With regard to transects, the increases in the indices seem largely attributable to grass species, which are dominant in the community, especially in the middle of the growth season compared to the end.

Densities in 1999 (Fig. 6.29), although higher than in 1998, were not significantly different.

The plant biomass index was greater in 1999 (Fig. 6.30). This was probably because the 1999 samples included more robust plants, as sampling took place earlier in the growth season in 1999 and therefore would not include end-of-season dieback, like the 1998 samples.

As the 1998 samples were taken towards the end of the growth season, and the substrate was therefore drier, it was not surprising to find that the conditions of the ash dam environment were such that space between plants (zero cover) was promoted instead of larger canopies (crown cover; Fig. 6.31). The limiting effect of dry conditions would be less of a restriction in the middle of the growth season, when the 1999 samples were taken, explaining the increased percentage of crown cover provided by plants and thus the reduced amount of space between plants.

The greater proportion of plants in the latter stages of their life cycles in the *Lepidium bonariensis-Eragrostis trichophora* plant community variant in 1998 on PFA-dam A (Fig. 6.32), and the converse increased proportion of plants in the middle stages of their life cycles in 1999, was probably due to sampling the plant community at different points in the growth season, as overall densities (see Section 6.11.2) did not differ between the two years.

These results in 1999 were congruous with those found in 1998 in this plant community variant, and although the sub-dominant species composition was slightly different, the principal dominant species remained unaltered.

The differences between 1998 and 1999 were slight, and arose mainly from sampling at different points in the growth season.

Thus the overall effect of gerbil impact was similar for both years, species richness was increased and dominance by few grass species was reduced. The coarser, drier substrate of abandoned zones seemed to accelerate plant life-cycles, reduce biomass and encourage the establishment of ruderal forbs after gerbils moved away.

CHAPTER 7

CONCLUSIONS

7.1 Effects on substrate

Highveld Gerbils on the PFA-dams at Hendrina Power station excavated vast quantities of ash, but this "ecosystem engineering" (Reichman & Seabloom 2002) by *Tatera brantsii* was transient, because colonies moved over time as they depleted local resources (Korn & Korn 1989). Direct, nutrient-enrichment effects (increased nitrates, organic Carbon & Phosphorous) by gerbils had insufficient time to accumulate, and, unlike the more permanent burrows of other fossorial small mammals, these burrows were soon abandoned and collapsed, mixing soil horizons. The resulting, more friable substrate, facilitates water infiltration (Whitford & Kay 1999), but it also more permeable to air, drying out more easily. In addition, many of the water-retaining, silt-sized ash particles (Aitken *et al.* 1984), excavated by gerbils are blown away by the wind (Thurlow 1937).

Water infiltration and mixing were the principal ways that the substrate chemistry of the PFA-dam was altered, and distinctive concentrations of pH, salinity and elements associated with the topsoil or the ash, were erased as a consequence of gerbil digging. The resulting substrate is more homogeneous, and this may benefit plants in that the potentially toxic components of the substrate are spread throughout the area of disturbance, rather than concentrated in a particular area.

7.2 Effects on plants

The main effect by gerbils on the plant community of PFA-dam A was an increase in the number of species, which was similar to the effect that many burrowing small mammals have in natural habitats (Martinsen *et al.* 1990; Dean & Milton 1991b; Stockrham *et al.* 1993; Huntly & Reichman 1994).

Biomass, and thus cover, was slightly reduced by gerbil impact, and plant life-cycles seemed hastened in the drier, abandoned areas. Density, especially of forbs, was increased, and dominance by small numbers of grass species was diminished. The sub-dominant species composition was slightly different, but the principal dominant species remained unaltered

7.3 Answers to questions posed at start of the study

It appears as if gerbil impacts are significant in the rehabilitated PFA-dam ecosystem. They seem to benefit the area studied by facilitating pedogenesis, increasing the depth of the substrate useable by plants, and ameliorating some of the extreme chemical conditions of the ash.

The plant community was slightly more diverse, following gerbil impact, and consisted of many more species that originally sampled in controls.

However, the density of gerbils was high (Vermaak 2000), and as a consequence, their burrowing impact could have been disproportionate. Considerable quantities of ash were brought to the surface, complicating the rehabilitation effort, and possibly requiring further expenditure in the future.

This density of gerbils also seemed to slow the process of succession on the PFA-dam, resulting in a longer period before the ecosystem could reach a sustainable climax state.

Most of the results found in this study are in accordance with those found for *T. brantsii* in savanna by Korn & Korn (1989). Dominance by grasses was reduced, and their biomass was lower at the end of the growth season. The number of forb species was increased, but legumes did not appear to be favoured. Diversity was slightly higher at the end of the growth season, but evenness was not changed by gerbil activities.

Species richness, was however, significantly increased by gerbil activities, even though many new species were annual forbs of a ruderal nature.

7.4 Recommendations and possibilities for future research

Lower densities of *Tatera brantsii* may be beneficial to the ecological rehabilitation effort of PFA-dams at Hendrina power station.

They appear to assist the development of the topsoil, mixing horizons and distributing nutrients more evenly.

They also seem to promote a more diverse plant community which is not dominated by tussocks of grass, and therefore vulnerable to erosion. Stoloniferous grass species are less affected by burial under excavated substrates and help stabilise the soil.

To achieve a lower stable population of *T. brantsii* it is recommended that perches for raptors be installed across the PFA-dams, thereby allowing the birds a different hunting strategem, which may be more effective. The more numerous rodent species are likely to be hunted first, and as *T. brantsii* is numerically dominant on the plateaux of the PFA-dams, its population should be reduced.

Perhaps the gerbil population could be reduced to the point where gerbil impact will aid the rehabilitation effort, rather than overwhelm it.

CHAPTER 8

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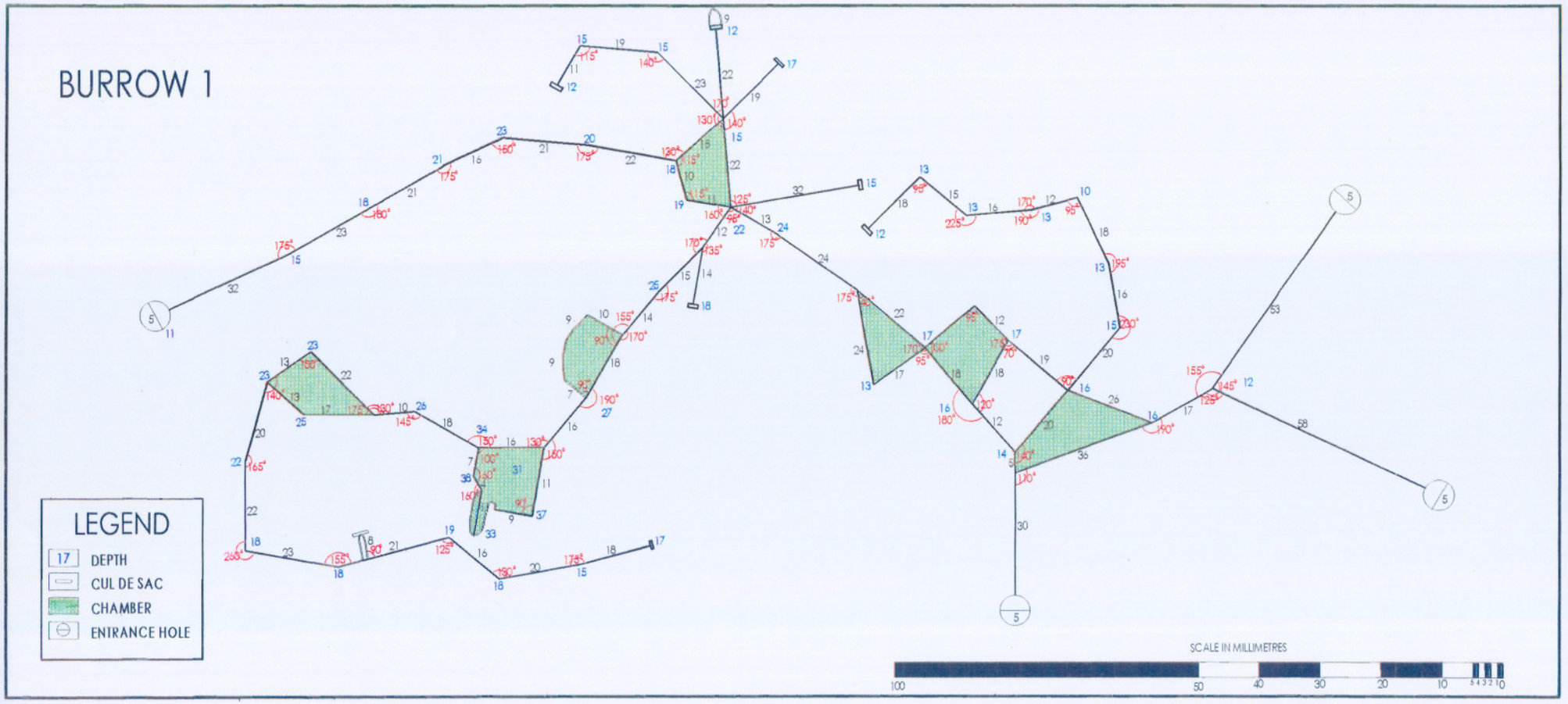
APPENDIX 1

Burrow System Maps


BURROW 1
LEGEND
17 DEPTH
CUL DE SAC
CHAMBER
ENTRANCE HOLE
SCALE IN MILLIMETRES
100
50
40
30
20
10
5 4 3 2 1 0

BURROW 2

LEGE

12 DEPTH

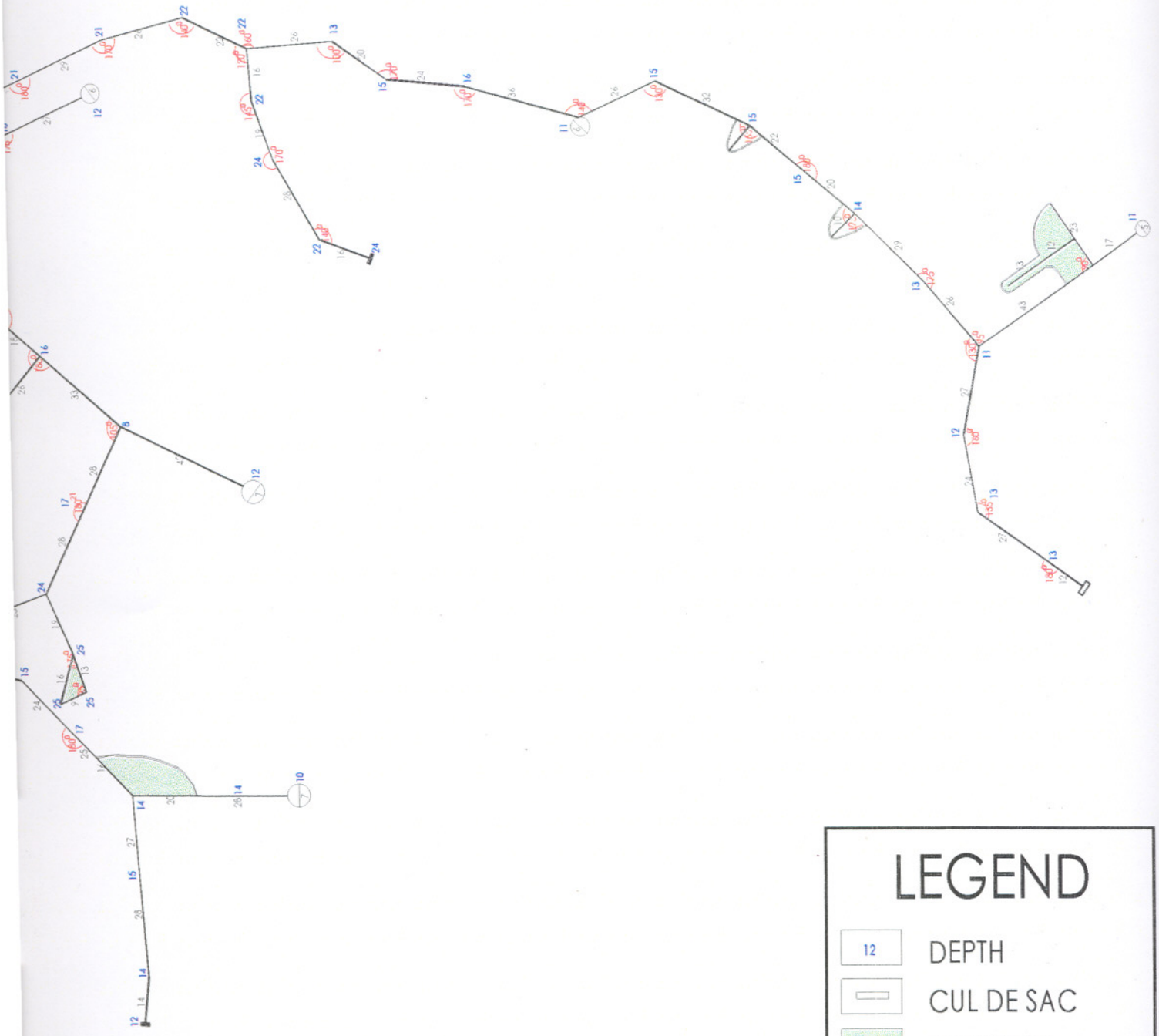
CUL DE

CHAMBI

ENTRAN

SCALE IN MILLIMETRES

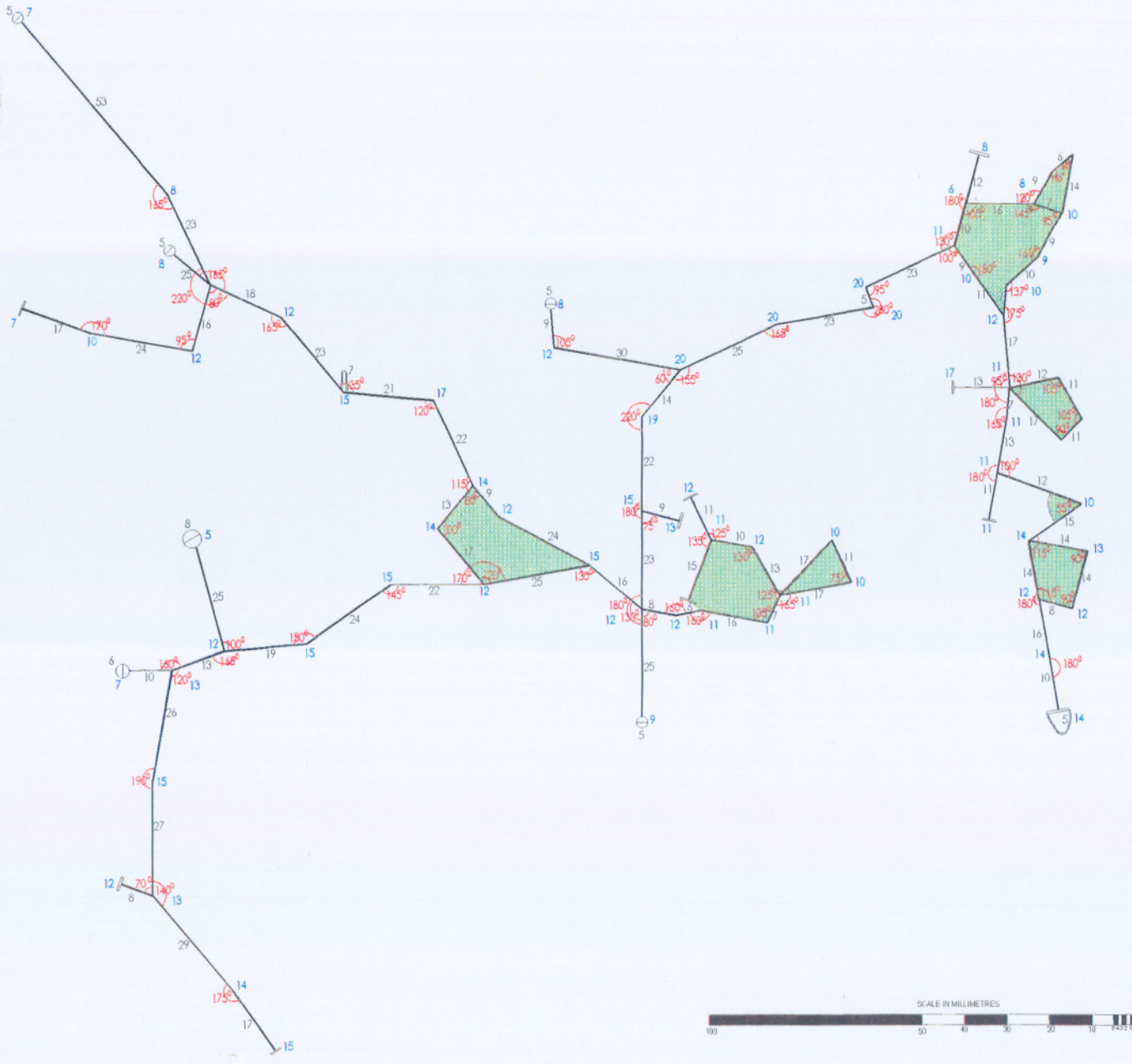
OW 2



LEGEND

12	DEPTH
	CUL DE SAC
	CHAMBER
	ENTRANCE HOLE

BURROW 3

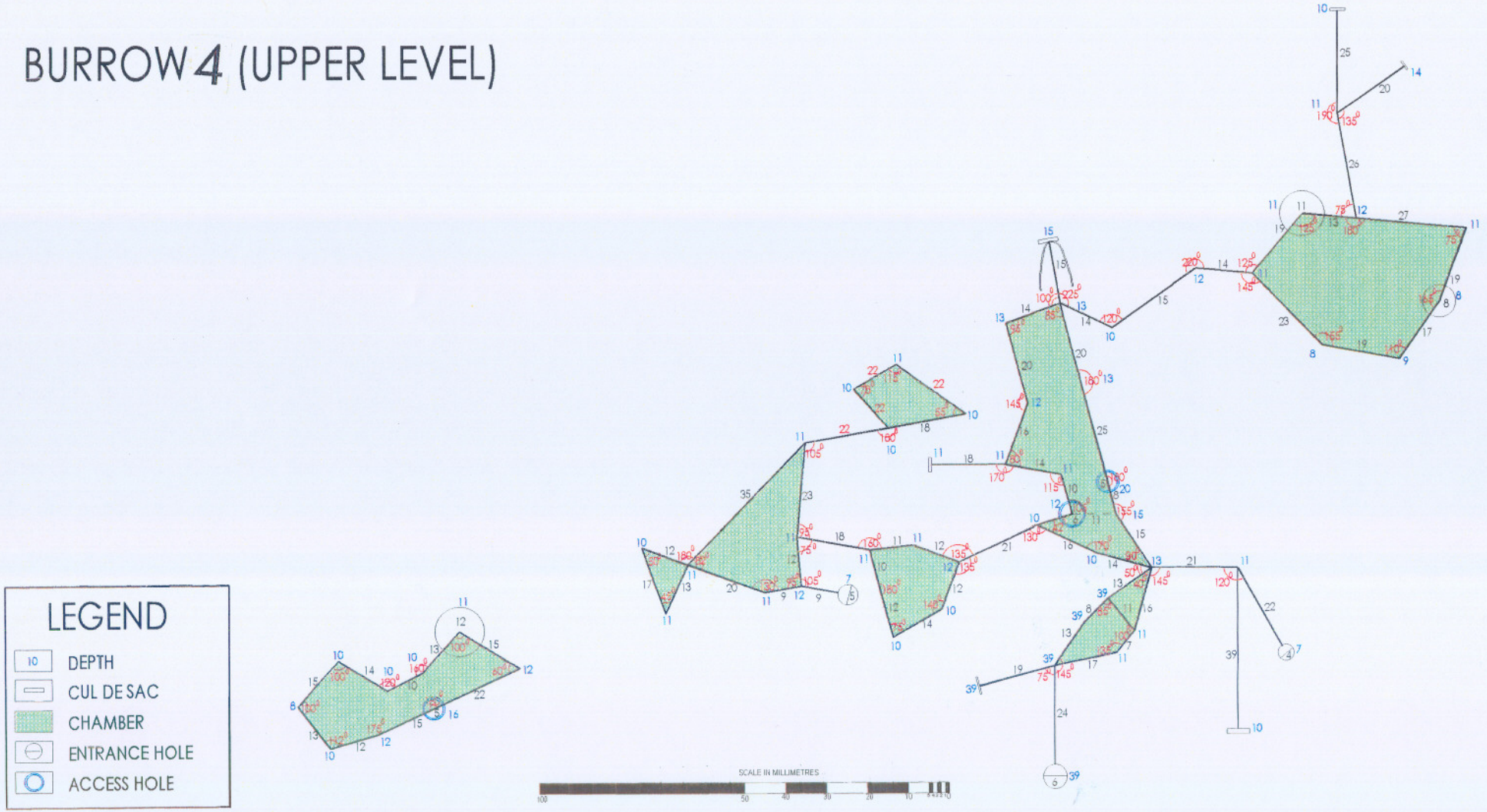


LEGEND

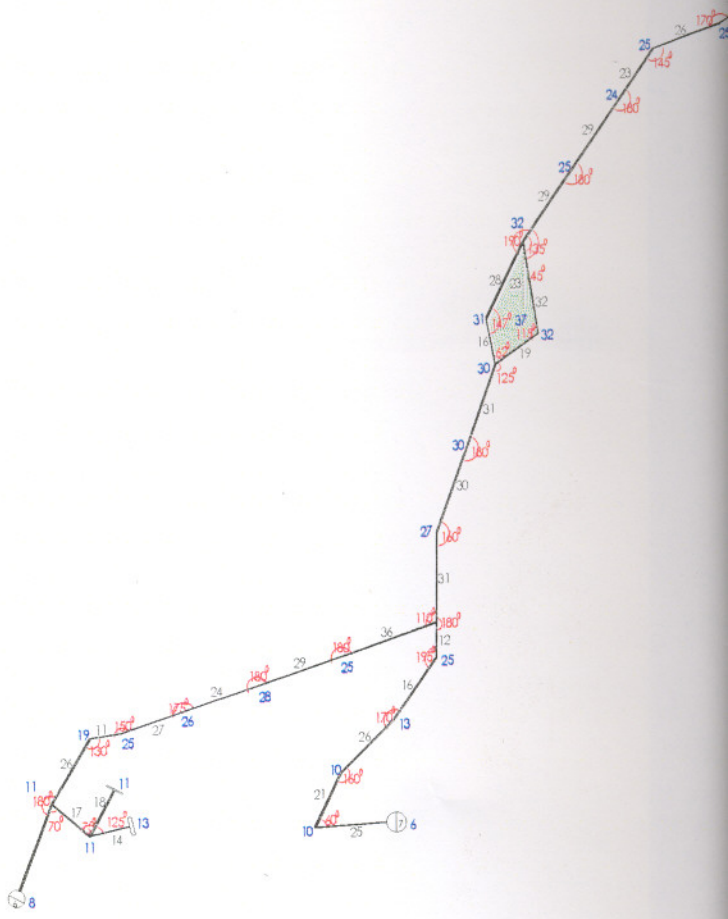
- 12 DEPTH
- CUL DE SAC
- CHAMBER
- ENTRANCE HOLE

SCALE IN MILLIMETRES

BURROW 4 (UPPER LEVEL)

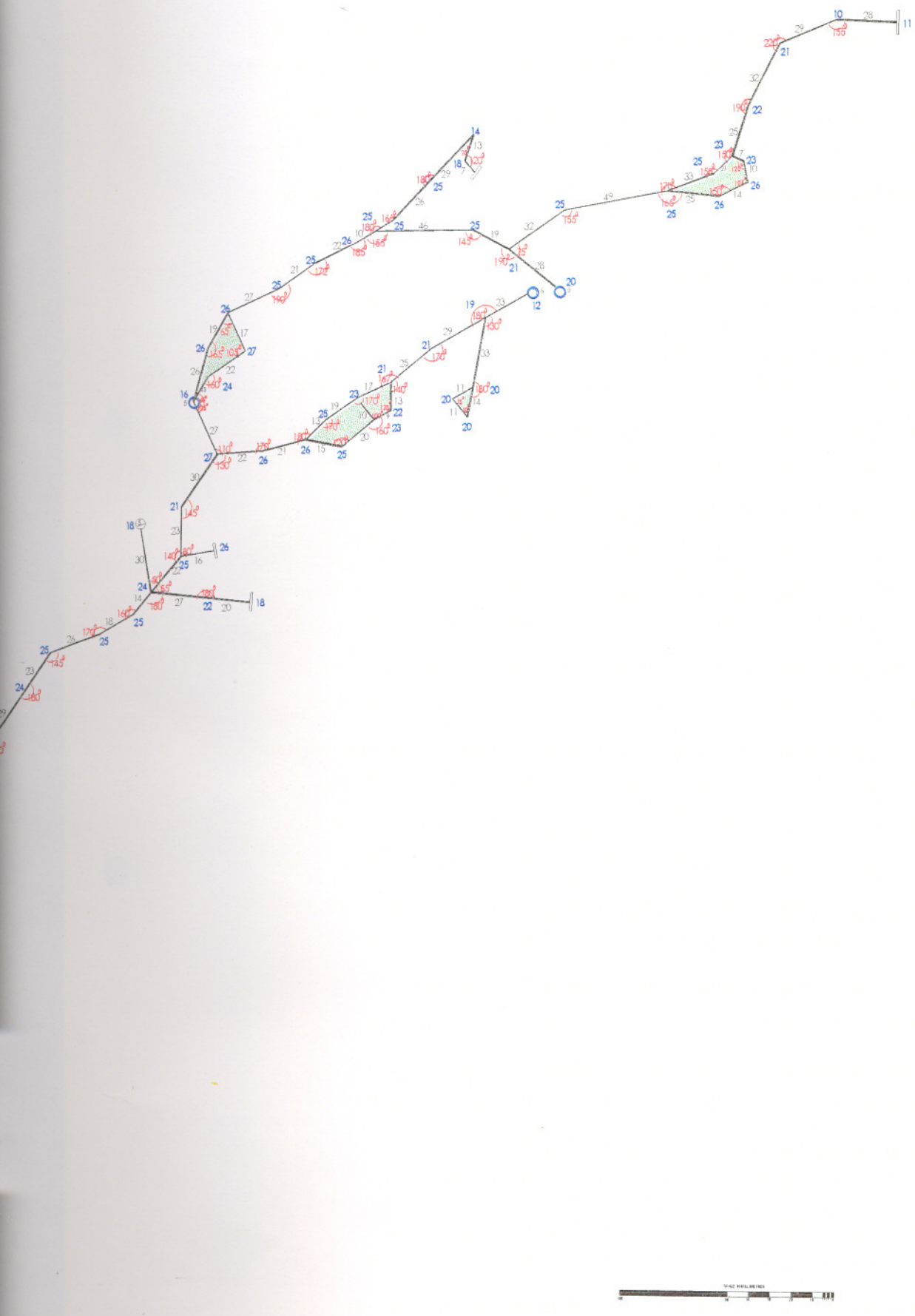


BURROW 4 (LOWER LEVEL)

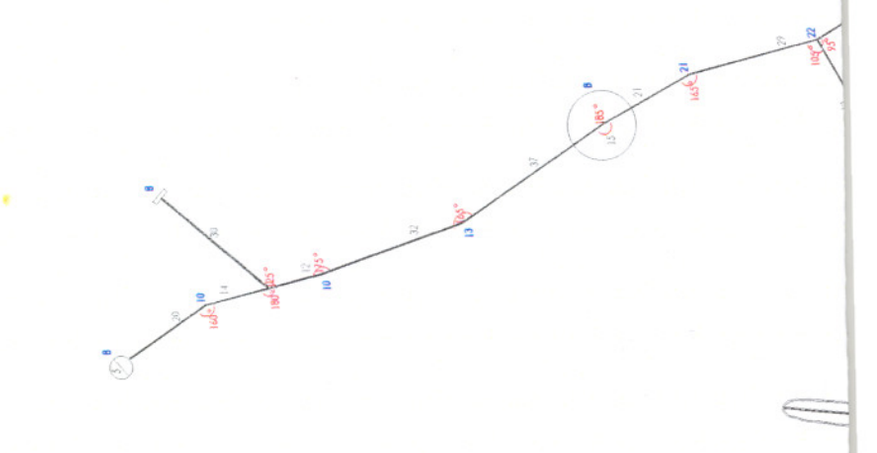


LEGEND

- 8 DEPTH
- CUL DE SAC
- CHAMBER
- ENTRANCE HOLE
- ACCESS HOLE

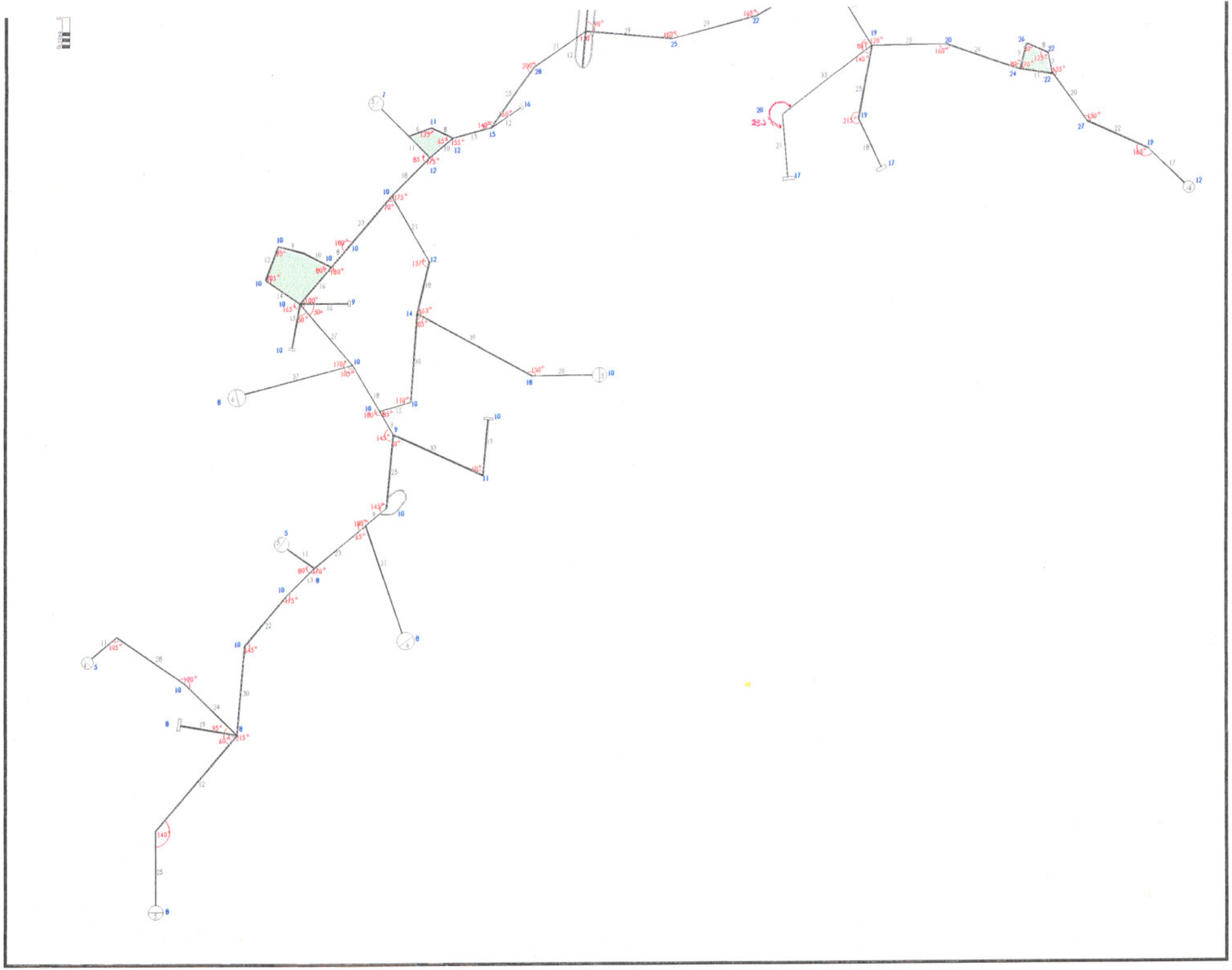


BURROW 5



LEGEND

8	DEPTH
	CUL DE SAC
	CHAMBER
	ENTRANCE HOLE

SCALE IN MILLIMETRES

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