

The Rehabilitation of the Asbestos Mine Area, Cyprus

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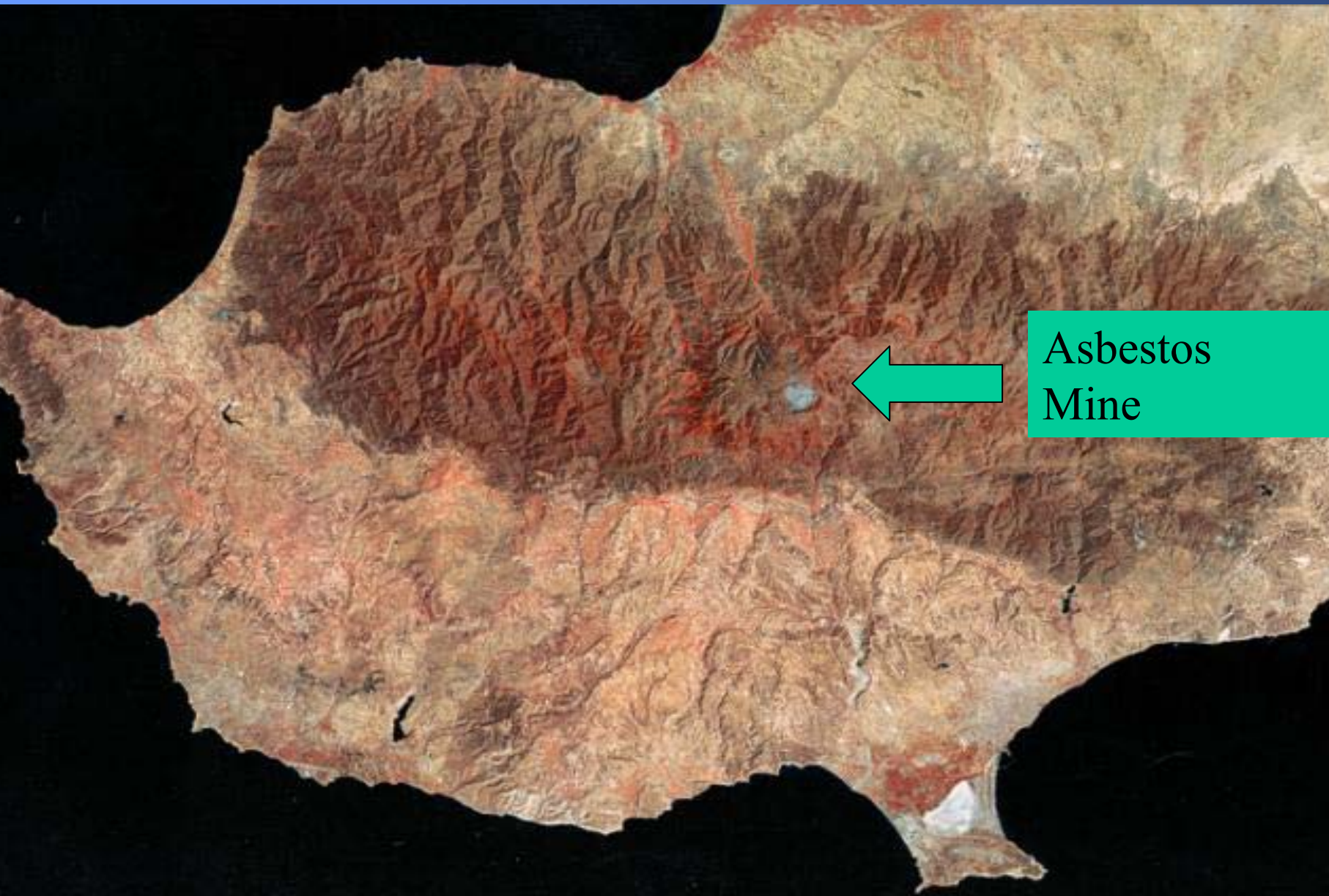
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Cyprus is considered as one of the most ancient sources of Asbestos especially during the Classic and Roman times.

- Incineration/cremation sheets
- Lamp wicks
- Shoes
- Protective coating for houses

The Cyprus Asbestos Mine is situated right in the heart of Troodos forest, over an extensively serpentinitized outcrop of hurtzburgite exposed over the central part of Troodos Ophiolite Complex



Asbestos
Mine

- Mining of Chrysotile asbestos
- Mining lease covers a surface of 6,5 square kilometres
- Opencast type
- asbestos has been exploited since 1904

- Mining operations started on a small scale and involved manual processes of digging and picking
- 1950 large-scale mechanization was applied for the mining and the beneficiation process, including crushing and milling, screening , fiberising and aspiration



Zypern. Amisnedos









BITTER LEMONS

Lawrence Durrell (1954)

- “.....It lies against the side of a mountain which has been clumsily raped. The houses, factories and shacks are powdered white as if after a heavy snowfall ; mounds of white snow rise in every direction, filling the still airs of the mountain with the thin dust of asbestos . Men and women walked about in this moon-landscape, powdered into ghoulis insignificance by the dust....”

- Recovery 1,4 to 1,6% of the ore milled
annual production of fibers
20.000-40.000 tons
- from 1904 until 1988 when the mining
activities were terminated, about
130.000.000 tons of rock were mined
and about 1.000.000 tons of asbestos fibers
were produced.

- economic benefits from mining
- adverse effects on the environment
 - the enormous open pit
 - the extensive waste tips
 - pollution of the soil/water
 - stability of the waste tips
 - the barren nature of the tips





Mine Operators

- 1905 Cesar Trombetta
- 1916 Compania Miner(Austria)
- 1919 seized by Government
- 1919 sold to S.Araouzos
- 1934 sold to Cyprus Mines(99 yr lease)
- 1985 Cyprus Mines faces financial troubles
- 1986 sold to Limassol Metropolis
- 1988 operations suspended
- 1990 Company liquidated

- The sudden closure of the mine in 1988, left the entire problem not only of the instability of the waste tips, but the overall environmental havoc created by the long mining history, needing badly mitigation measures
- The sudden closure did not allow any programmed closing down procedures to be initiated

Rehabilitation

- 1995 preliminary appraisal of all issues involved
- course of action was undertaken by a multidisciplinary technical committee
- Emphasis was placed on the stabilization of the waste tips.
- D/s slopes of tips are situated approximately 1 Km u/s of Kato Amiantos

- An ambitious plan was drawn up aiming to stabilize the tip slopes and rehabilitate to the greater possible extent the huge pit area and to reforest the whole area, bringing the site as close as possible to its pristine condition

Waste tips

Old waste tips –limited area 35 Ha

New waste tips-1,3 Km long Loumata valley
60 MCM 100m high-drainage gallery
along valley

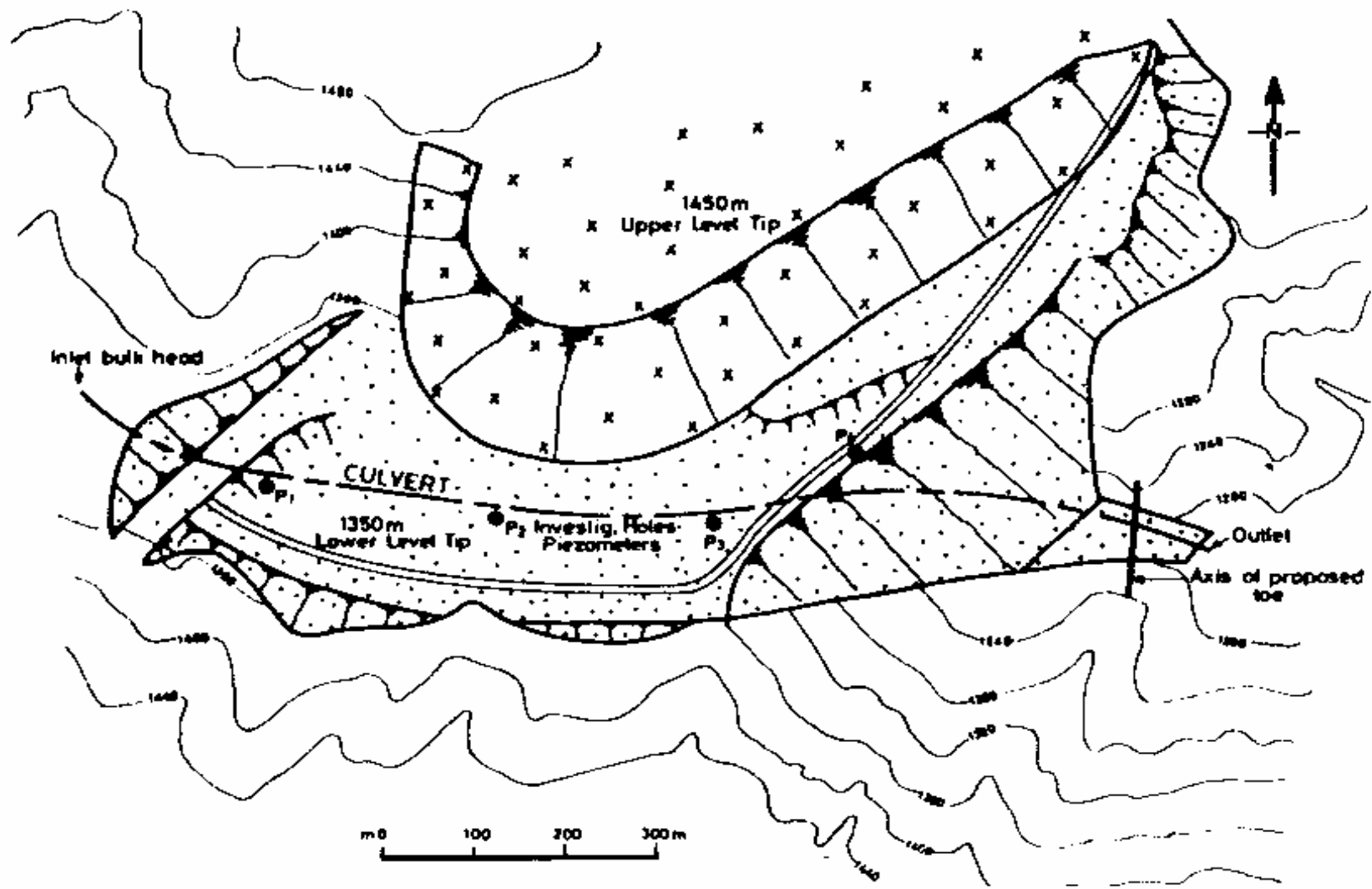


Fig. 1 Plan of Loumata Tip and Investigation Boreholes later turned to Piezometers. Elevation in meters amsl

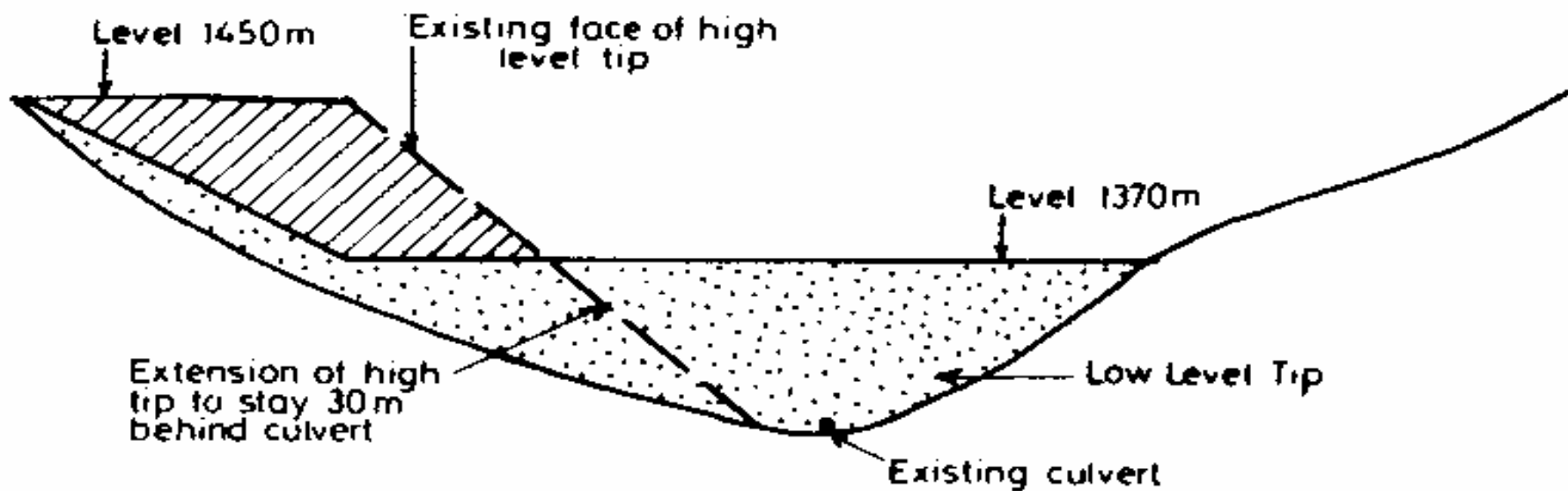
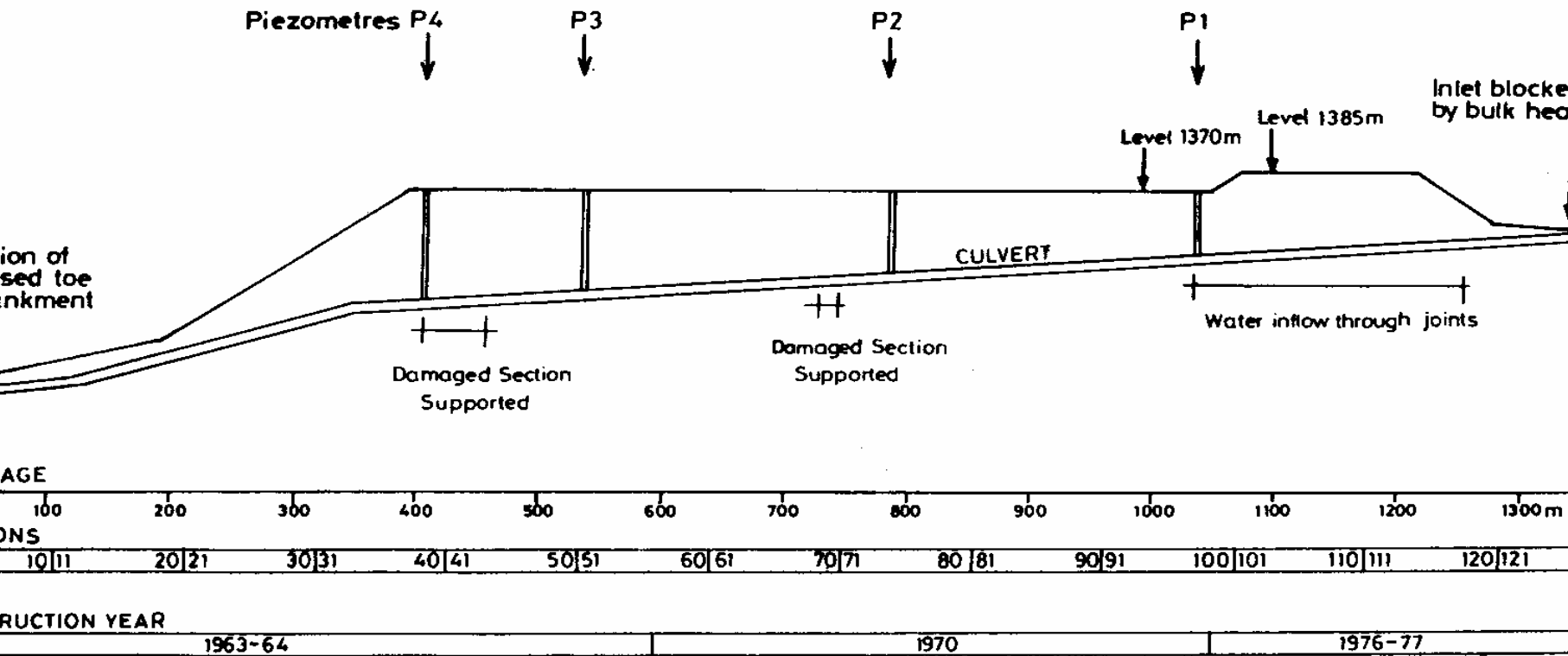


Fig.3 Typical Cross Section across Loumata Valey Tip.



2 Longitudinal Section along culvert and existing Loumata Valley Tip

Reprofiling

dictated by safety, environmental and other practical reasons

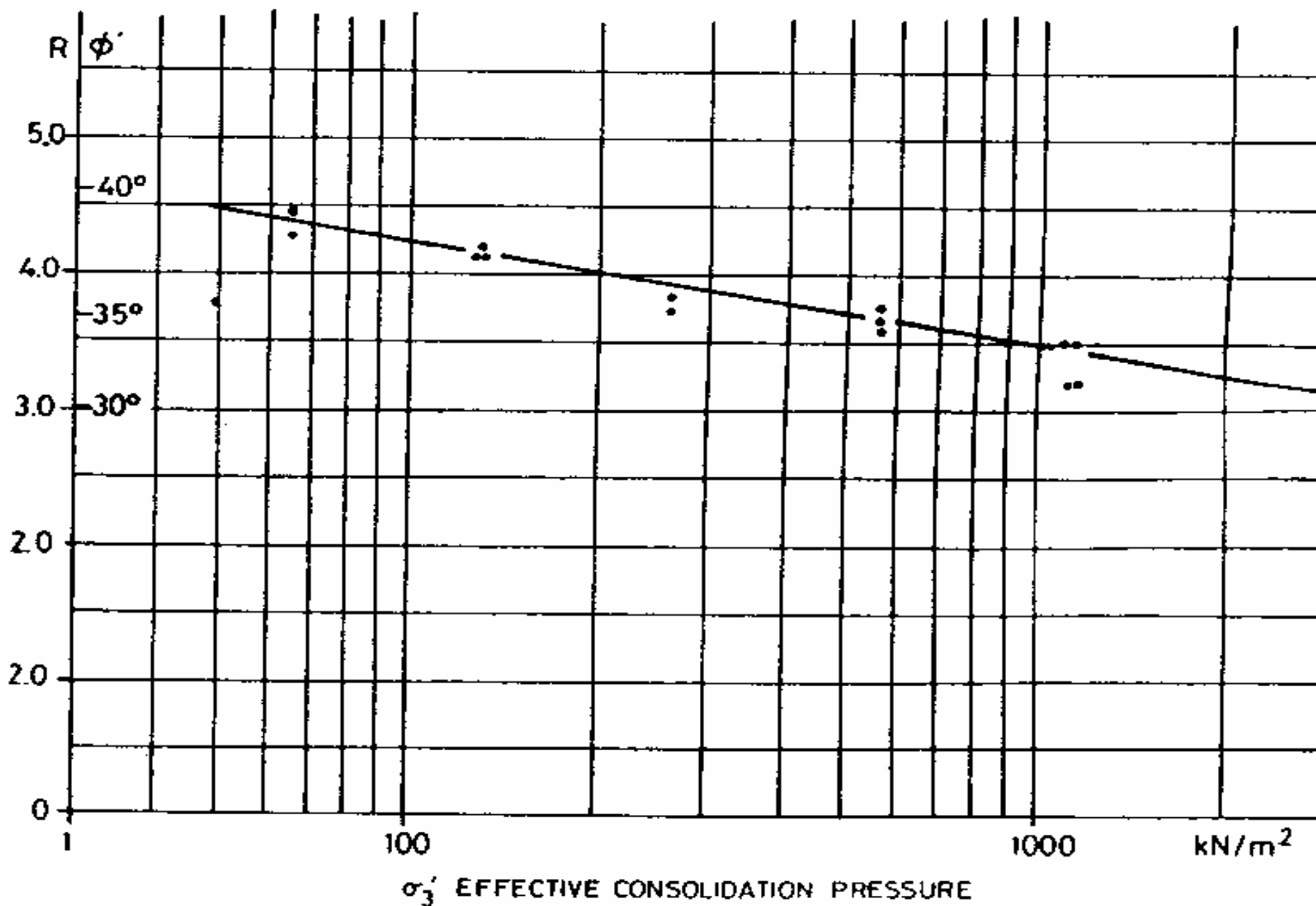
- stabilize waste tips
- intercept surface water flows
- slopes to blend with the rest of the environment.
- slopes to facilitate reforestation

Liquefaction

- Liquefaction occurs under conditions of full saturation when the materials are subject to cycling loading such as in the case of a serious earthquake
- Considering grading, water table and SPT tests (Seed et al., 1984) it was concluded that liquefaction is not possible

Slope stability analyses

- static loading
- earthquake loading, pseudostatic stability analyses
- Calculation of displacements(Newmark, 1965)



Variation of stress R and angle of shearing resistance ϕ' with consolidation pressure

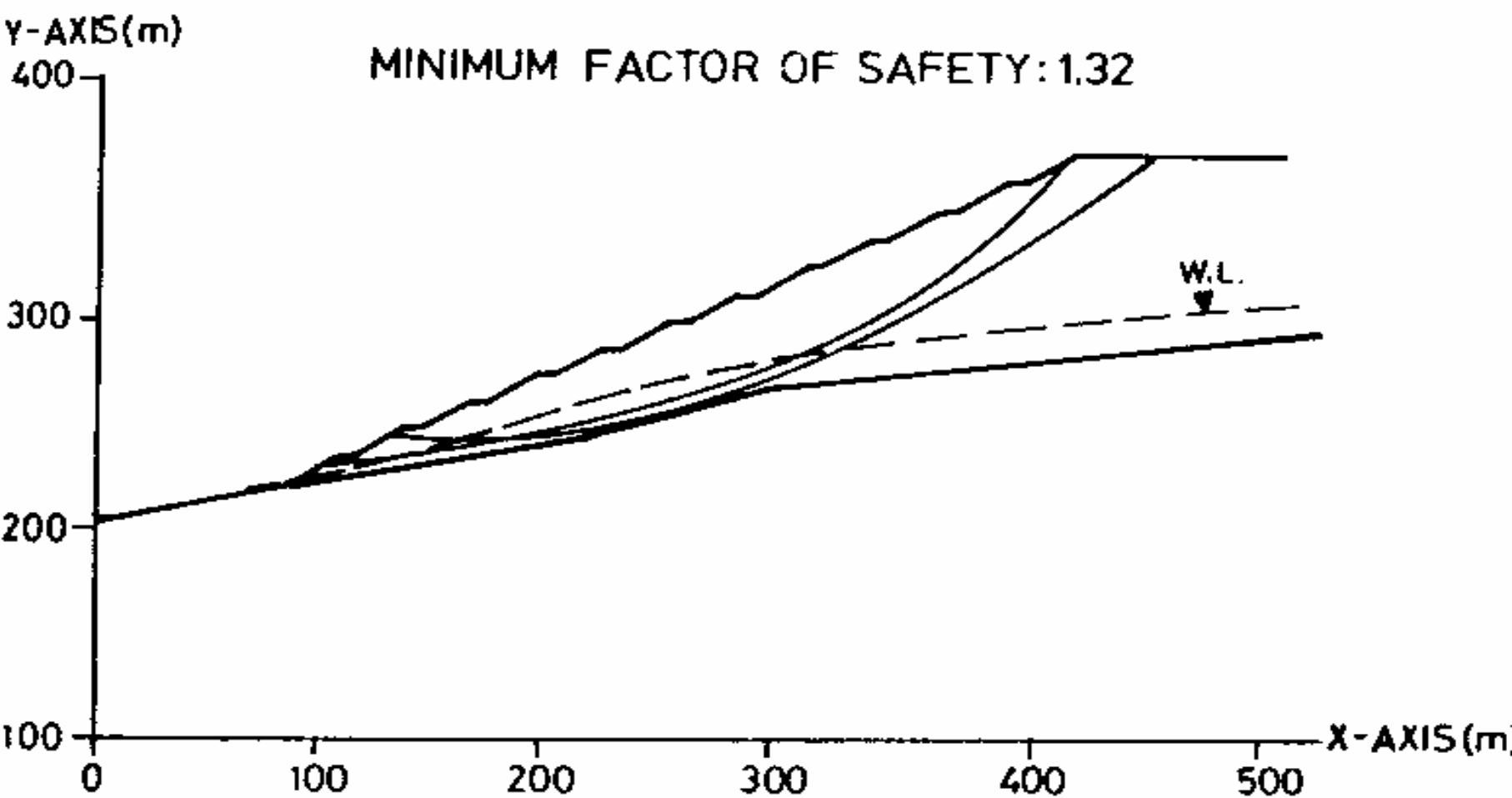


Fig. 6 Loumata Tip Static Analysis

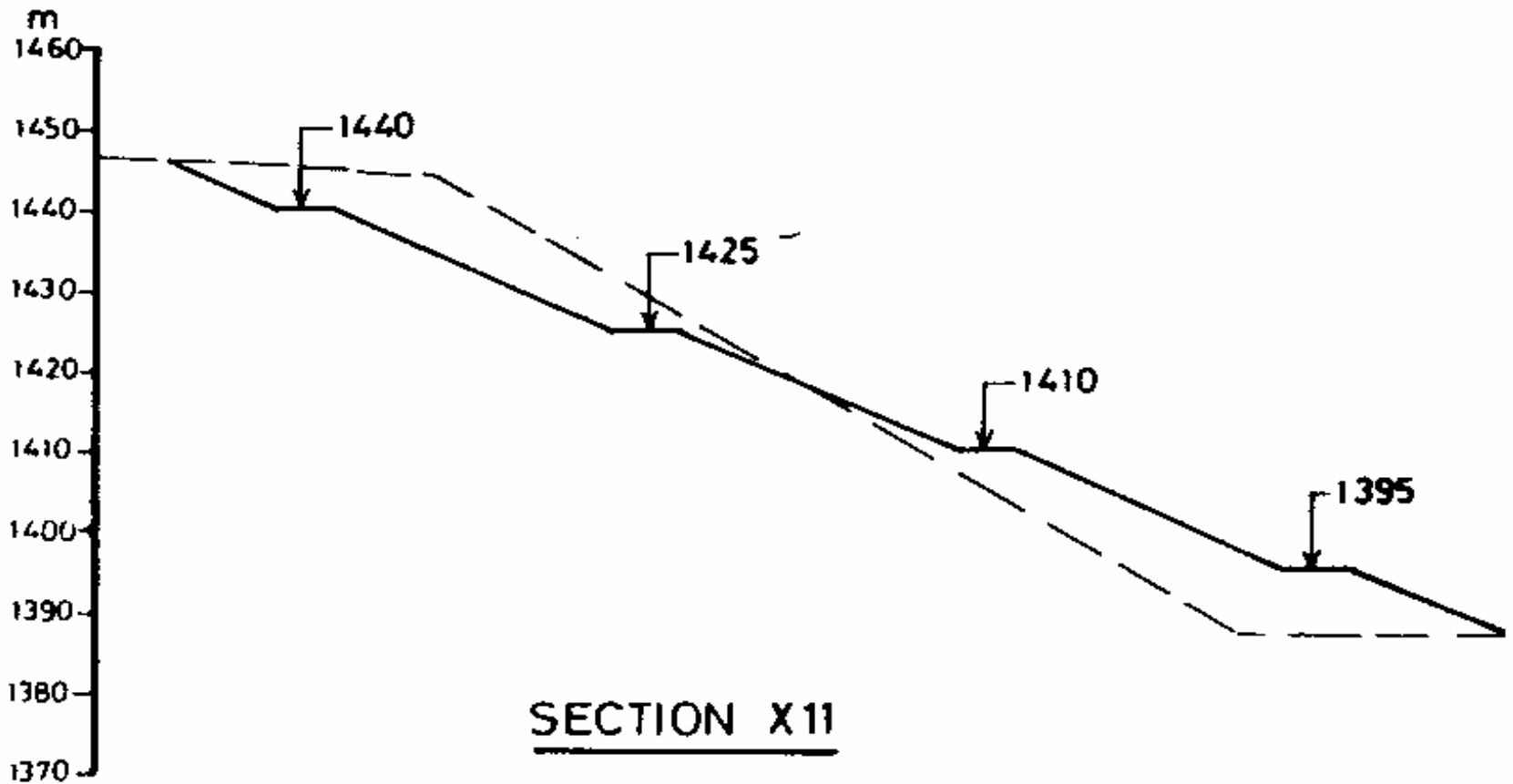
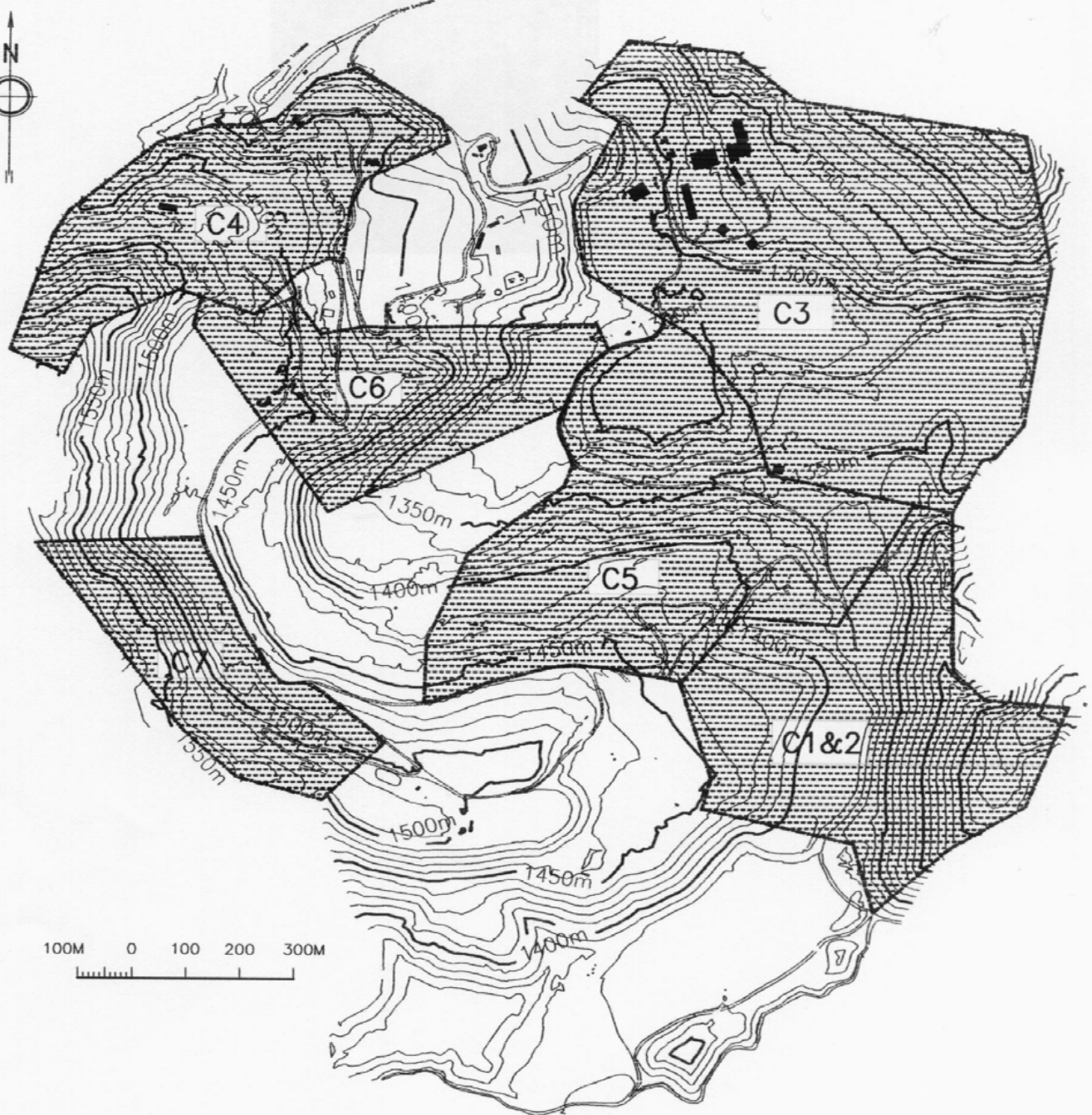


Fig.4 Typical Section adopted in the 1996 Reprofiting Contract

Earthworks contracts

- Reprofilng works formed an enormous task not only because of the huge volumes of material involved but also because of the ragged environment and the difficult winter weather conditions.
- Due to budgetary and other practical reasons -work under medium size contracts
- Seven contracts have been completed till now, representing about 70% of the total earthworks

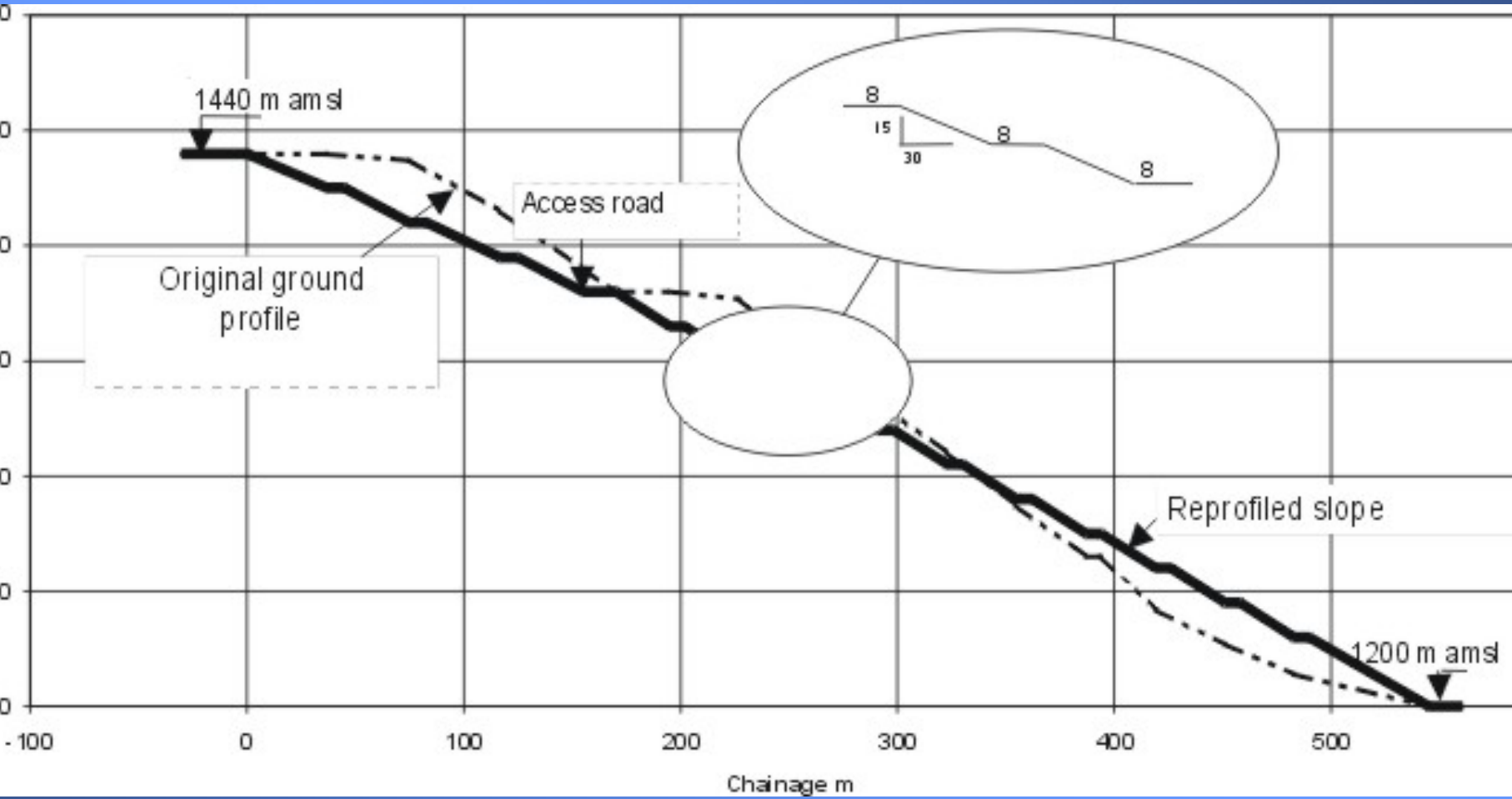


- All contracts completed to date involved the excavation and placement of some 3.6 million cubic metres of material, at a total cost of some 1.7 million Cyprus pounds (appr. 2.9 million Euros). Earthworks commenced in 1996 with a target to complete all works in the mine area within a decade





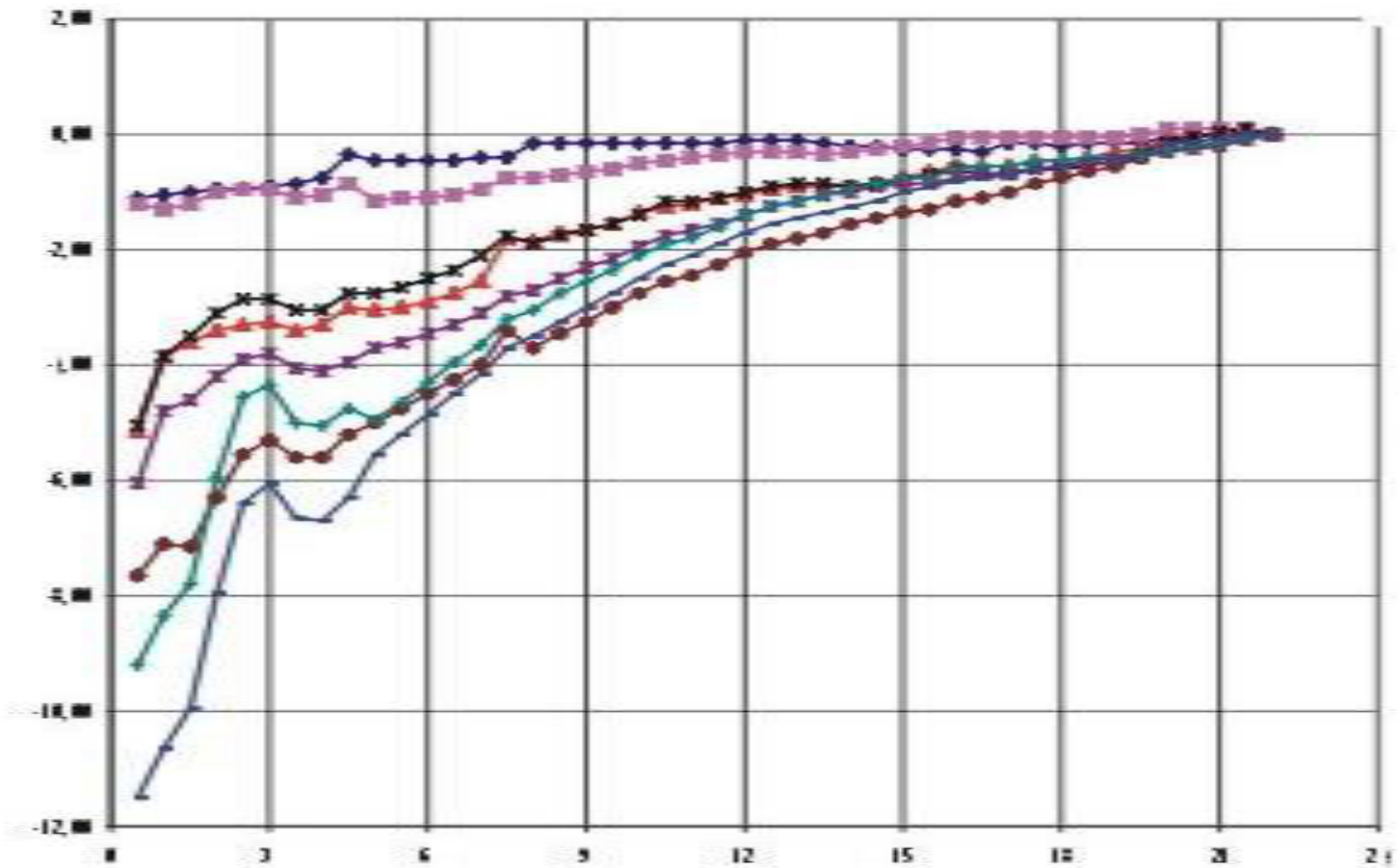




Monitoring of movements

- **for safety reasons and better understanding of the mechanical behaviour of the waste material**
- **measurement of surface and deep seated ground movements and water levels**
- **movements recorded to date indicate that the old tips are prone to small creep type movements .**

AMANTO 5 MNE
OLDWA 5TE TIP5 - INCLINOMETER HOLE 11-ABPLANE



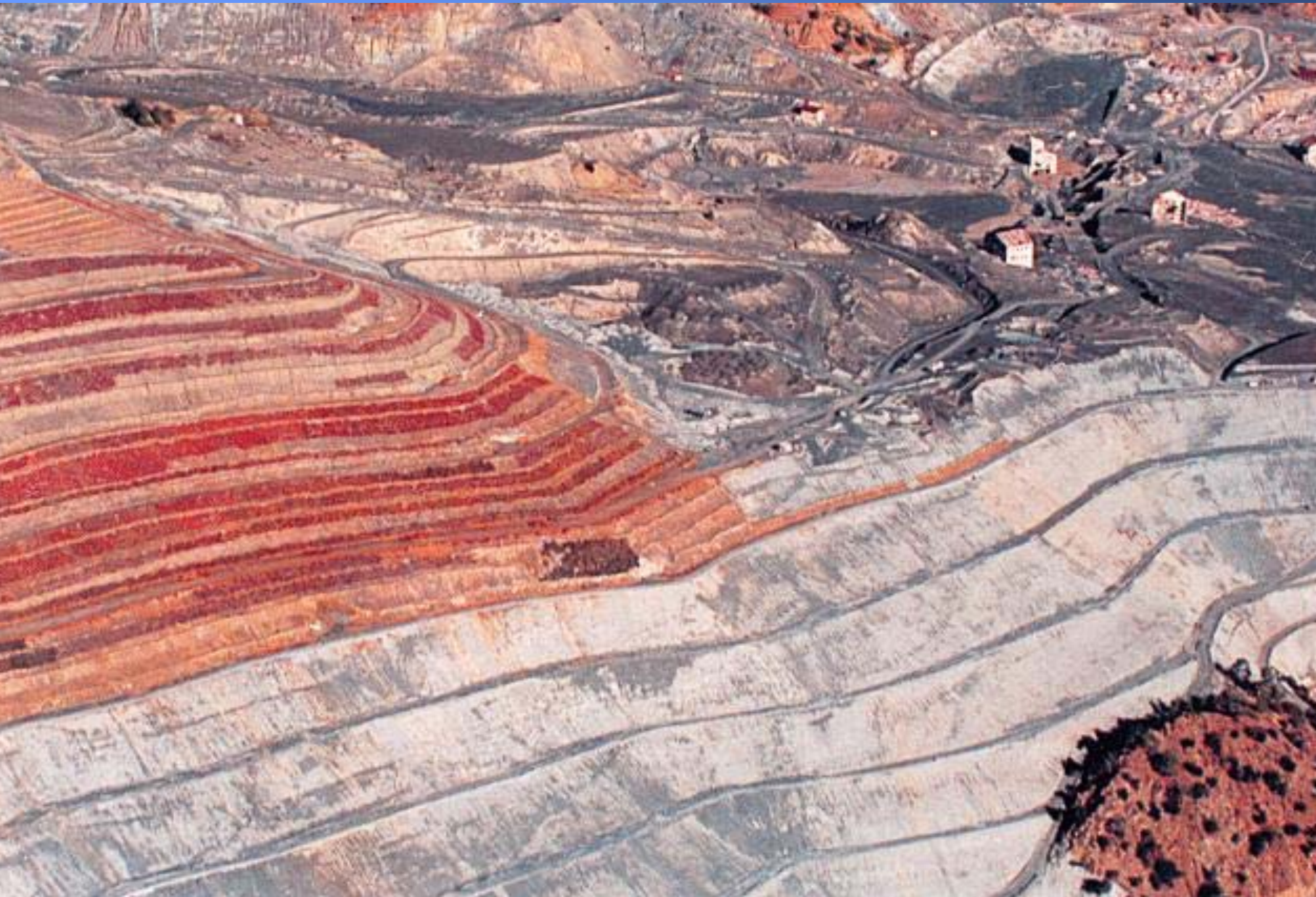
Reforestation

- Reforestation forms an integral part of the Asbestos Mine rehabilitation works
- Planned and executed by the Forestry Department, after consultations with the Technical Committee.

- On the level berms two trenches 0.8 m deep are opened and filled with topsoil transported from neighbouring areas.
- Distance between trenches about 5 m to allow access for trucks for unloading topsoil.
- space between trenches covered with topsoil appr. 30 cm in thickness.

- On the slopes, two secondary terraces 1,2 m wide, are prepared and two additional trenches are opened, one at the base of the slope, and a similar one at its top.
- All surfaces covered with fertile topsoil and protected with thatching
- About 4000 cubic meters of topsoil are required for the reforestation of a hectare.

- Planting is carried out along trenches and secondary terraces
- All other surfaces are sown with a mixture of seeds from different perennial plant species.
- Species used for planting :
- *Pinus brutia*, *Cedrus brevifolia*, *Rhus coriaria*, *Robinia pseudoacacia*, *Cupressus sempervirens*, *Quercus alnifolia*, *Arbutus andrachne*, *Sorbus aria*, *Juniperus foetidissima*, *Clematis vitalba*, *Pistacia terebinthus* etc











Risk assessment study(2003)

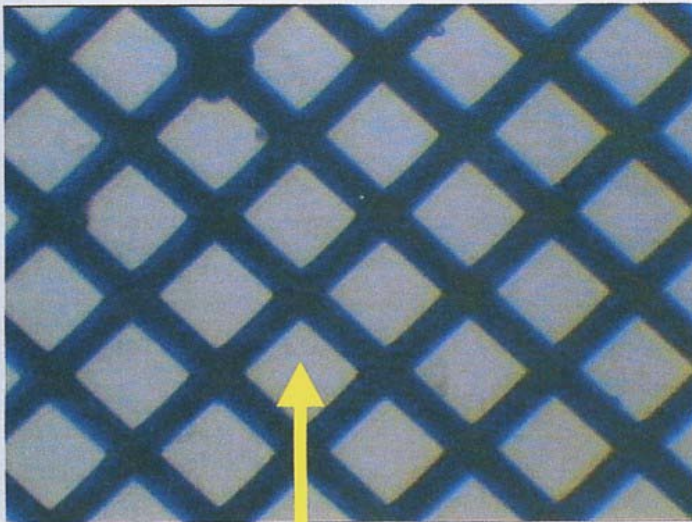
- To study the risk to the general public and to find out if people are being exposed to asbestos fibers today, identify the hazard, evaluate the existing rehabilitation works and propose remediation measures to reduce possible risks.

Asbestos sampling and analyses TEM

(Transmission Electron Microscopy)



Grid



0,0094 mm²



TEM (x 10.000)

CONCLUSIONS

- In 1995 the task of rehabilitation looked enormous . There was lack of previous case studies
- Contrary to the negative belief that prevailed prior to the commencement of the works it is now apparent that the barren environment of the asbestos mine is likely to improve dramatically in the forthcoming years

Thank you

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