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1986/67. Potential landslide and erosion problems, Great Western Tiers and Mt Barrow.

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Abstract

Geological and topographical maps covering areas of Forestry Commission operations have been examined in order to provide a preliminary indication of areas of potential erosion and landslide risk.

The areas examined, on the slopes of the Great Western Tiers and South Barrow escarpment, have topographic features which strongly reflect the varying resistance to erosion of the underlying bedrock. The salient features are steep talus and scree covered upper escarpment slopes below cliffs of erosion resistant dolerite, and pronounced slope benches with associated steep slopes at their margins, located on the middle to lower escarpment profile. In some areas the slope benches have been dissected by streams with associated steep head and valley slopes.

Slopes steeper than 20° (35%) on most rock types have the highest risk of potential erosion and landslide problems, and should therefore remain undisturbed. Slopes between 15° (25%) and 20° (35%) are known to have failed elsewhere and therefore are at high risk. Slopes between 15° (25%) and 12° (21%) have been known to fail in some cases, particularly where embankments have been excavated. Slopes below 12° (21%) are considered stable.

Soils developed on sandstone and granodiorite on slopes above 12° should be recognised as particularly sensitive to erosion. Other soils, especially on Triassic and Permian mudstone and siltstone, may be prone to tunnel erosion.

In order to assess the potential hazards, areas of proposed operations should be compared with regions of similar topography and rock type where forestry operations are currently proceeding or have been completed. This should be followed by inspection of the potential problem areas in the region where operations are proposed. This assessment should result in the planning of operations with regard to the perceived hazards.

Forestry Commission guideline procedures for erosion control should be implemented during, and immediately after, forest operations.

INTRODUCTION

The guidelines presented in this report are based on a background of investigations of landslide and erosion problems in many parts of the State. The majority of investigations involve slopes of the Tamar Valley and the North-west Coast which are underlain by Tertiary basalt and clay. Several

investigations have been conducted elsewhere, including Quaternary talus and Triassic and Permian rock slopes of the East Coast, Fingal area and Cluan Tier. Permian and Triassic slopes and landslides have also been investigated in the Lilydale, southern Midlands and southeastern parts of the State. Erosion problems have been investigated on several of these rock types, as well as on areas of the North-east, underlain by highly erodible granite soils.

The relationship between topography and the underlying geology, as well as an understanding of the nature of the rock types, their weathering products and susceptibility to erosion and landsliding, are important starting points towards an understanding of the behaviour of slopes after the removal of vegetation. The potential effects of erosion processes can therefore be anticipated and appropriate forestry practices adjusted. The planning of all operations should acknowledge the sensitivity of the landscape to accelerated erosion and potential mass movement.

The location of forestry coupe numbers referred to in this text are shown in Figure 1. For the purposes of this report the terms erosion and landslides have been separated. The term erosion will be used to cover sheet, rill, gully and tunnel erosion forms and processes.

TOPOGRAPHY

The general topographic setting of all the areas under investigation can be summarised as follows.

The topography is characterised by a high plateau, the Central Plateau, or Mt Barrow in the case of BS11, with an undulating surface and a gentle slope to the south. The plateau has an altitude of approximately 1200 m with steep, near vertical escarpments at its margins. The upper part of the escarpment, or Great Western Tiers, is often cliffed up to 150 m in height with thick scree and talus mantles at the cliff base. Below the erosion resistant rocks of the upper escarpment levels the slopes are steep and often benched or stepped in profile. The steeper sections are generally between 20° and 30° in slope, the flatter benches being below 12° in slope. The benched nature of the slope is due to the differential erosion of the underlying rocks.

To the north of the Tiers isolated hills and ridges represent erosional monadnocks, capped by remnants of the resistant upper escarpment rocks. Warners Sugarloaf [HU 7] is one such example, resulting from dissection of the Tiers by Warners Creek and the Meander River.

The lower escarpment slopes occur approximately between the 550 m and 400 m contours. The middle and lower escarpment slopes are often deeply dissected by the headwaters of major streams and rivers. Some streams have breached the Tiers escarpment and drain small areas of the plateau surface but most are insequent

LOCALITY MAP - FORESTRY AREAS GREAT WESTERN TIERS AND MT BARROW

1 : 50 000

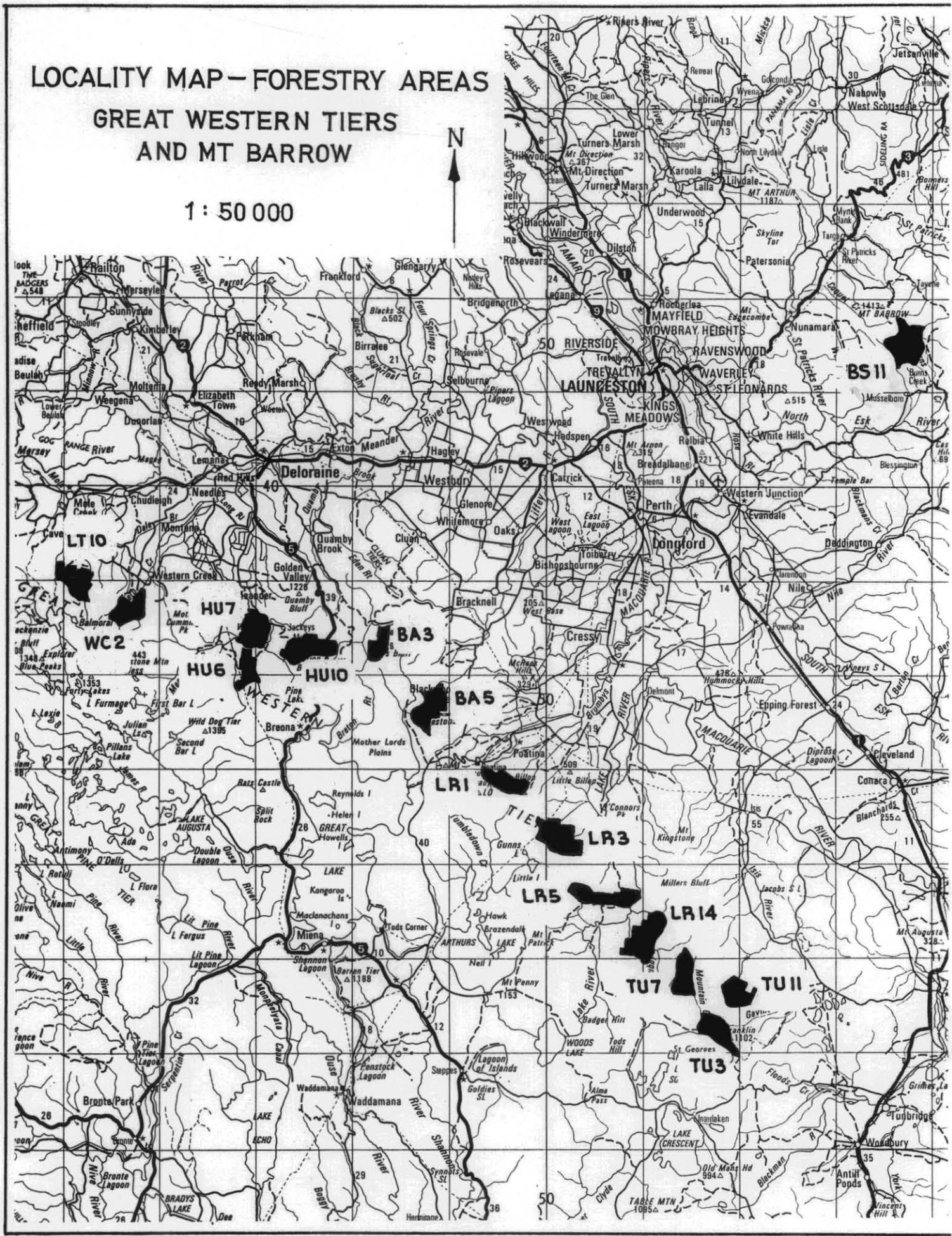
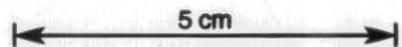


Figure 1.



and drain the escarpment slopes. Most streams closely parallel the direction of slope of the escarpment and the dissected stream valley sides and heads often have long, steep slopes.

Forestry coupe BS11, on the south-east slopes of South Barrow, has a similar topographic setting to the slopes of the Tiers escarpment.

The general topography of each of the areas under investigation is summarised below. The coupe number and broad topographic setting is followed by the altitude range. The last part of the summary provides a more detailed description of the topography of each area, including the approximate altitude range of major slope and benched sections.

BA 5. TIERS- east facing, middle to upper escarpment, deeply dissected. 900-500 m. Steep side and head slopes of Westons Rivulet and Brumbys Creek. Minor benching at head of Westons Rivulet. Remnant benches on major spur, northern part, 650-700 m, 780-870 m.

HU 10. TIERS- north facing, upper to middle escarpment, heavily dissected. 1000-550 m. Steep side and head slopes of Burles, Bernies and Warners Creeks. Dissected bench remnants on spurs, 750-1000 m.

BA 3. DRYs BLUFF- north-west facing, middle to upper escarpment, deeply dissected. 900-500 m. Steep side and head slopes of Pages and Quinns Creek. Remnant benches on ridges and spurs, 950-850 m, 750-700 m, 730-650 m.

LR 1. TIERS- north facing, middle to upper escarpment slopes. 900-450 m. Major benches 850-720 m and 640-550 m. Simple benched profile.

WC 2. TIERS- north facing, middle to lower escarpment slopes. 850-450 m. Steep upper slopes and areas adjacent to Western Creek. Major bench 750-650 m, dissected by Western Creek. Steep slope segment at edge of bench, 650-670 m. Moderate to low slopes 600-450 m.

LT 10. TIERS- north facing, middle to lower escarpment slopes. 970-350 m. Steep slopes 900-600 m. Benches 970-930 m, 700-600 m, 850-800 m, not continuous. Major benches and moderate slopes 600-350 m.

HU 6. TIERS- north facing, lower upper to lower escarpment slopes. 950-400 m. Steep slopes 950-600 m. Fragmented bench 800-900 m. Low slopes 600-400 m.

BS 11. SOUTH BARROW- South-east facing, upper to lower escarpment slopes. 1150-750 m. Major bench 1000-950 m in southern part, 1080-1000 m in northern part. Local steep slopes adjacent to Beckett, Burns and Musselboro Creeks. Low slopes 900-750 m.

LR 3. TIERS- north facing, major ridge in northern part of area. 900-400 m. Minor steep slopes 900-800 m. Isolated steep slopes 800-500 m at head of Abrahams and First Creeks.

HU 7. WARNERS SUGARLOAF- central peak. 800-350 m. Steeper slopes 650-800 m. Benches 650-520 m and 500-450 m on south-east side.

LR 14. CENTRAL PLATEAU- dissected ridge, Stevensons Lookout. 1000-500 m. Moderate slopes steepening towards ridge crests.

TU 11. TIERS- east facing slope, upper and middle escarpment slopes. 1000-400 m. Moderate slopes 1000-600 m. Low slopes 600-400 m.

LR 5. TIERS- southern slope of Threshermans Hill- Maclanachan Sugarloaf. 1100-500 m. Moderate to low slopes. Small steep sections near eastern end of ridge.

TU 3. CENTRAL PLATEAU- North-west facing slope. Lake Sorell. 1080-800 m. Moderate to low slopes.

TU 7. CENTRAL PLATEAU- Low ridge. 1070-840 m. Low slopes.

GEOLOGY

The various rock types which underlie the areas under investigation are briefly described below. Normally the rock types are described in order of decreasing age, however for the purposes of this investigation the important parameters are the rock type and weathering products and the relationship to the topography. Therefore the rock descriptions are arranged in descending order, as they outcrop on the Tiers escarpment slopes. The rock descriptions are based on the One Mile Geological Map Series Explanatory Reports. These reports include Middlesex (Jennings, 1963), Launceston (Longman, 1966), and Quamby (Pike, 1973).

JURASSIC DOLERITE. [Jd]. The Central Plateau and South Barrow are underlain by Jurassic dolerite, which crops out as cliffs at the head of the upper escarpment slopes. The dolerite is in the form of fairly flat lying sill-like sheets which have intruded both Triassic and Permian strata. The overlying rocks have been subsequently removed by erosion and the exposed upper surface of the dolerite sheet has itself been eroded. Dolerite also caps Warners Sugarloaf. The position of the lower contact of the dolerite is often mantled by slope deposits, but interpretation can be made from the escarpment slope morphology and isolated contact exposures. The base of the dolerite is approximately accordant at 1000 m but at Warners Sugarloaf [HU 7] and on the eastern face of the Tiers the sill is more transgressive in nature and the lower contact is approximately between 700 m and 600 m.

QUATERNARY DEPOSITS

DOLERITE SCREE [Qs]. Scree slopes are found immediately at the base of the dolerite cliffs of the upper escarpment. The scree slopes have an irregular surface which dips generally at about 30°, the angle of repose of the material. They consist of accumulations of rock fragments up to six metres in diameter with little or no matrix. The dolerite rock fragments have been shed from the cliffs by processes involving ice wedging, frost action and gravity.

DOLERITE TALUS [Qtd]. Mass wasting of the dolerite escarpment of the Tiers and South Barrow has produced extensive deposits of dolerite talus. The talus consists of weathered and unweathered dolerite blocks in a yellow-brown to red-brown silty and clayey matrix. The dolerite boulders vary in size up to six metres across and sporadic sandstone blocks derived from the Triassic sandstone cliffs may also be included. Some talus composed of angular blocks of quartz sandstone in a light grey sandy matrix is usually found close to the base of the Triassic sandstone scarps.

The talus extends downslope from the cliff base as tongues and mantles. The downslope movement of the talus materials was probably due to periglacial solifluction processes during the Pleistocene glacial periods. The scree and talus mantles may obscure the stepped slope profile of the upper escarpment as the deposits often overlie the benches formed by the Triassic sandstones and in some cases, the Permian rocks. In some areas (WC 2, LT 10) the talus tongues or 'rock glaciers' (Jennings 1963) are mapped separately with the symbol Qg.

TRIASSIC SANDSTONE [Tr]. Below the steep upper escarpment cliffs and slopes, the benched middle to lower escarpment slopes are underlain by sedimentary rocks of Triassic and Permian age. Triassic rocks immediately underlie the dolerite along the north-facing slopes of the Tiers. These rocks generally form a pronounced bench and crop out distinctively as cliffs or steep slopes at the edge of this bench. The Triassic rocks are up to 350 m thick and largely consist of feldspathic sandstone with shale bands. The upper sections have occasional siltstone, carbonaceous shale and coal bands. The major sandstone unit is known as the Ross Sandstone and its relative resistance to erosion results in the persistent cliffed outcrops. Towards the eastern end of the Tiers the Triassic rocks are largely absent beneath the dolerite.

PERMIAN SEDIMENTS. The boundary between the thick sandstone and shale sequences of the Triassic rocks and the underlying rocks of Permian age is largely conformable. The boundary generally occurs at an altitude of about 700 m but varies in places between 900 m and 600 m. These virtually flat-lying Permian rocks crop out on the middle to lower escarpment slopes in the form of benches, a result of differential erosion of the various rock units. The Permian rocks are up to about 600 m in total thickness and range from mudstone to sandstone and

conglomerate. The nature of the various formations and groups of Permian rocks which are present in the area under investigation are summarised below. They are arranged in descending order, as they crop out on the Tiers escarpment slopes.

JACKEY FORMATION [Pj]. Sandstone and shale underlying the Triassic Ross sandstone. Topographically forms small benches below the steep slopes and cliffs at the edge of the Ross sandstone bench. Up to 43 m thick.

BOGAN GAP GROUP [Pb]. Predominantly grey quartz and mica mudstone. Contains a thin, resistant sandstone and conglomerate horizon. The Palmer sandstone unit is three to five metres thick and often crops out as cliffs and associated benches. The Blackwood conglomerate unit varies between 1.5 m and 0.9 m in thickness and also forms a distinct topographic bench.

POATINA GROUP [Pp]. These rocks consist of up to 87 m of marine mudstone and sandstone. The sequence is: an upper sandstone unit (9-14 m); a mudstone unit (9 m); another sandstone unit (8-12 m); and a basal mudstone unit (62 m). The mudstones are easily weathered and the sandstone units are resistant to erosion, forming benches and associated outcrop scarps.

WOODBRIDGE GLACIALS [Pw]. Isolated outcrops of mudstone with minor sandstone. Average thickness on northern face of Tiers is 76 m.

LIFFEY GROUP [Pl]. Brown carbonaceous quartz and quartz mica sandstone with minor carbonaceous shale. Up to 35 m thick. The rocks crop out as persistent benches and cliffs, generally at the base of the upper escarpment slopes.

KANSAS CREEK BEDS [Pkb]. Up to 58 m of pebbly siltstone overlying a sandstone unit about six metres thick. The sandstone often forms topographic benches. Conglomerate forms the basal unit.

QUAMBY MUDSTONE [Pq]. Dark grey mudstone.

FERNTREE GROUP [Pf]. These rocks are a correlate of the Bogan Gap Group and can therefore be considered similar to the description above.

LOWER PERMIAN. [Pm and Pmc in coupe BS 11]. A basal conglomerate up to 45 m thick overlain by an easily weathered grey mudstone up to 90 m in thickness.

GRANODIORITE [Dg], of Devonian age underlies the south-east half of BS 11. Weathered materials are easily eroded.

The geological information has been plotted on topographic maps of each area at a scale of 1:25 000. The information has been obtained from the Tasmanian Geological Atlas 1:50 000 and 1:63 360 Series. These map sheets include Great Lake (Blake et

a l., 1956), Middlesex (Jennings et a l., 1958), Launceston (Longman et a l., 1964), Quamby (Barton et a l., 196), Lake River (Matthews, 1974), and Interlaken (Forsyth, 1986).

EROSION AND LANDSLIDE HAZARDS

Soil erosion is a particular hazard associated with forestry operations in the areas under investigation. The hazard must be assessed according to the critical land features such as topography and geology. Once the hazards have been assessed operations can be planned according to the assessment. However, operation planning must be sufficiently flexible in order to allow adjustment if further hazards occur or increase.

Accelerated erosion of the soil by rainfall and runoff, in the form of sheet, gully, rill and tunnel erosion, as well as landslide mass movement, are all considered to be potential hazards in areas of forestry operations. The rate of erosion is governed by the length and steepness of slope, surface roughness, the intensity of rainfall runoff, the nature of the soil or rock weathering products, the vegetative cover, and land use and management (Sloane, 1983a). The soil is considered to be the weathered products of the *in situ* bedrock and includes unconsolidated deposits such as talus. In many instances these deposits will vary in thickness on a local scale, according to such things as the nature of the bedrock, groundwater conditions, and slope aspect.

A brief outline of erosion forms and known landslide occurrences will be presented, together with a summary of the potential erosion susceptibility of rock types. It should be noted that this advice is generalised, as this is not a field assessment report, and the information scale is based on 1:50 000 and 1:63 360 geological and topographic maps.

SOIL EROSION

Sheet Erosion.

Sheet erosion is considered by Pinkard (1980) to be the greatest hazard, as a large part of the area has steep or long slopes and relatively unstable soils. Pinkard (1980) and Ritchley (1978), consider that sheet erosion is most severe on the upper slopes and crests of hills and mountains in the higher rainfall areas. All soils are susceptible to some extent, but a ranking in order of decreasing susceptibility related to rock type would be; granodiorite, Triassic sandstone and sandstone talus, Permian sandstone, Permian mudstone, dolerite talus and dolerite.

Sheet erosion is an insidious process and usually progresses unnoticed until more serious effects such as rilling and gullying occur. The net result is a loss of topsoil and associated soil nutrients.

Rill and Gully Erosion.

Rill and gully erosion is a further development of sheet erosion and forms where concentrated runoff erodes to form well defined channels or rills and gullies. Sloane (1983a) considers that gullying develops on middle to lower slope areas where soils are often thickest. Continued concentration of runoff into the gullies leads to rapid progression upslope by headward extension. Soils which are prone to gullying are generally unstable with sandy surface layers. The rilling and gullying of roadside embankments and gravel pits is a major problem as siltation of drains may occur, resulting in road damage and a ready source of sediment for further transport by runoff. A similar ranking in terms of rock type can be used as that suggested for sheet erosion.

Tunnel Erosion.

Tunnel erosion is a potential problem where subsoil clays have dispersive properties. Deeply weathered profiles developed on Permian and Triassic shale and mudstone may be prone to this form of erosion, as tunnel erosion is prevalent on these rock types elsewhere in the State. Tunnelling usually results in deep gullying due to tunnel collapse.

In summary, potential hazards include sheet, rill, gully and tunnel erosion. Long steep slopes are potentially highly prone to erosion, as well as areas of major soil disturbance such as roads, snig tracks and landings. Granodiorite and Permian and Triassic sandstone are rock types of highest potential risk. The potential for tunnel erosion is highest on Permian and Triassic mudstone where the subsoil contains a high proportion of clay with dispersive properties. A detailed discussion of erosion forms and processes is presented by Sloane (1983a).

LANDSLIDES

Landslides have occurred elsewhere in the State on most of the rock types that are present in the areas under investigation. Long steep slopes with high groundwater tables are particularly susceptible. Landslides on Permian and Triassic rocks usually occur on deeply weathered profiles with high clay contents. From investigation of landslides elsewhere in the State, slopes above 15° have a high potential for failure. Slopes below 12° are considered stable, while slopes between 15° and 12° are potentially unstable and must therefore be treated with some caution.

Slopes underlain by dolerite talus are known to have failed in several parts of the State. Landslides have been inspected for the Forestry Commission in the Fingal and Mount Punter region as well as other areas of the East Coast (Sloane 1978, 1982.) Failures commonly occur where dolerite talus overlies sandstone bedrock and especially where the talus is thin and road embankments have been excavated to bedrock. Landslides in dolerite talus have also been seen in undisturbed areas with

natural vegetation. Slopes greater than 15° have a high potential for failure (Sloane, 1978). Slopes between 12° and 15° are known to have failed in some cases and therefore slopes in this category must be treated with some caution. Slopes less than 12° are considered stable, unless excavation results in embankments with bedrock exposed at the base.

Several landslides are shown on the Lake River and Middlesex geological maps. Other landslides have been located by the Forestry Commission. The landslides and associated topographic and geological locations are summarised below. The adjacent coupe reference is given.

LT 10. Middlesex geological map. Adjacent landslides on Permian Woodbridge Glacials and dolerite talus. Upper and middle escarpment slopes and steep slopes at the edge of major benches.

WC 2. Forestry landslide A. Dolerite talus overlying Triassic sandstone. Upper escarpment slopes.

HU 6. Forestry landslide F. Dolerite talus overlying Triassic sandstone. Upper escarpment slopes.

LR 1. Forestry landslides B,C,D,G. Dolerite talus overlying Triassic sandstone. Steep slopes at edge of major sandstone bench. Forestry landslide B has been inspected by B.D. Weldon and a report is included in Appendix 1.

LR 3. Forestry landslide E. Permian Poatina Group sediments. Steep slopes at incised edge of major bench.

LR 5. Lake River geological map. Landslide on adjacent slopes. Dolerite talus overlying Triassic sandstone. Upper escarpment slopes.

The evidence of previous instability is an important input in determining landslide risk. The morphological features associated with old landslides are summarised below.

Drainage.

Stream channels or gully depressions aligned across the slope rather than in a downslope direction. Swampy depressions, especially when associated with 'backsloping' slope segments, are caused by ponding of runoff by ground disturbance or fed by seepage from landslide headscarps.

Landslide morphology.

Head scarp- Arcuate area of steeper slope on an otherwise uniformly sloping area.

Slide mass- Often a semicircular 'backsloping' area caused by rotation during failure. May be hummocky and ridged across the slope. Ponding or swampy depression may be associated.

Toe region- Often lobate or tongue shaped in plan. Hummocky or bulged in profile. Seepages may be present at toe front.

Other features.

Slope complexity is often a good indicator of previous instability. This can be identified in the field or from topographic maps with a small contour interval. Areas of complex slope on an otherwise uniform or simple slope profile should be outlined.

Tension cracks are generally associated with active or recently active landslides and can occur in toe or slide mass regions or above head scarps.

Leaning trees or 'kinked' sections of trees often indicate slope instability during growth.

Several of these features may be associated, providing greater confirmation of previous instability.

In summary, landsliding may occur in dolerite talus, particularly on steep slopes at the edge of Triassic sandstone benches. Landslides may also occur on steep slopes underlain by thick mantles of weathered Permian and Triassic mudstones. Slopes greater than 20° are considered to be highly likely to fail and therefore should remain undisturbed. Slopes between 15° and 20° have a high potential for failure, particularly where the water table is high. Extreme caution must be exercised when disturbing slopes of this grade as the majority of landslides on these rock types occur on slopes above 15°. Slopes between 12° and 15° have a moderate risk of failure and therefore must be appropriately considered, particularly where roading results in embankment excavation. Slopes less than 12° are considered stable, although large excavations must be treated with caution.

RECOMMENDATIONS

The accompanying coupe maps (Appendix 2) have been enlarged from 1:50 000 topographic maps. The areas have been slope classed into three basic classes; greater than 20°, between 20° and 12°, and less than 12°. The topographic base was considered unsuitable to allow further subdivision and the classes were chosen to provide a broad outline of the salient topographic features described previously.

It is suggested that the initial input in outlining potential erosion and landslide hazard areas should be the slope classing of each area at the best topographic scale available. The suggested slope classes are described in the previous section on landsliding. This will initially identify the basic topographic units which can then be related to the geological information. This procedure will highlight those areas of

potential erosion and landslide hazard and allow a ranking in order of potential severity.

The methodology of further investigations should be similar to that employed by Sloane (1982, 1983a,b,c). The initial topographic and geological inputs will highlight potential problem areas, at a scale dependent on this baseline information scale. Similar areas already subjected to forestry operations should then be inspected in the field. This will improve the assessment of the erosion and landslide susceptibility of the various rock types, on the basis of previous experience. The final step should involve field inspection of the potential problem areas after the above steps have been implemented. During this assessment process all known occurrences of active landslides and erosion areas should be plotted on the coupe maps, together with areas which have been identified as old landslide areas. This will highlight sensitive topographic units which can be avoided and will also indicate similar topographic units which may be at risk. These similar topographic units may have no evidence of erosion or previous instability but if, for example, they are a continuation of a slope segment which has failed, then by inference the unfailed slope segment must be considered to be marginally stable. An example of this approach is provided by Sloane (1982), from brief investigations at Cluan Tier.

The end result of the above investigations should provide a basis for the planning of forestry operations with regard to the potential geological hazards described in this report. Sensitive areas will be indicated and therefore roading and clearfelling can be arranged in order to minimise potential hazards and the visual impact of these hazards. Despite a concern with visual impact, the overriding concern should be the minimisation of accelerated erosion in order to protect and preserve the soil for further operations. Sloane (1983c), considers that if large scale erosion occurs then not only is there a loss of soil, and consequently soil nutrients, but access to the area for the next cycle of forest harvesting may also be seriously affected.

Some of the field guidelines used in the Mount Funter and Cluan Tier areas (Sloane 1978, 1982) may also apply to the areas under investigation, particularly as there are basic topographical and geological similarities. In this region clearfelling and roading was restricted to the topographic benches wherever possible. Areas which were avoided included the steep slopes at the edge of the first major Triassic sandstone bench, especially where the dolerite talus mantle was thin. Road routes which traversed this slope were carefully chosen, as evidence of old landslides was common. The preferential location of access roads along ridges and benches was also considered by Sloane (1982, 1983c) to be a useful technique to avoid large scale excavation, as well as minimising the effect of roads as a main source of sediment for transport by rainfall runoff.

It is also recommended that there be a strict adherence to the Forestry 'Guidelines' (1981) in terms of the implementation of erosion control procedures during or immediately after clearfelling operations. The guidelines should not be strictly adhered to in the sense that once an area is classed in terms of erosion then the procedures to be followed are rigidly set. If local problems occur, the erosion class may require upgrading and this should be done at the field or district forester level. Field investigations with Forestry personnel have shown them to have an excellent local knowledge of the soils and their behaviour in relation to forestry operations. To a large extent therefore, decision making in respect to geological hazards should be made by field staff at the local level.

Ranking of proposed forest areas with reference to potential geological hazards.

The logging coupes under investigation have been ranked in decreasing order of potential geological hazard. To a large extent this is related to the percentage of the area with slope greater than 20°. Those areas which are deeply dissected by streams are considered more at risk than areas with simple benched profiles reflecting the underlying geology. Dissected regions may have a higher potential for groundwater seepage. The potential areas of hazard are summarised below.

BA 5. Large percentage of steep slopes. Only approximately one square kilometre of a major sandstone bench remnant with low slope and low hazard in western part of area. Remainder of area is deeply dissected with long steep slopes adjacent to streams and at the margin of the major sandstone bench below 750 m contour. Steep Triassic sandstone slopes at edge of bench may have high erosion potential. Steep slopes near the dolerite talus fringe have potential for failure. Steep lower slopes underlain by Permian Ferntree Mudstone have moderate to low erosion and landslide hazard unless soils are thick or the rock is deeply weathered.

HU 10. Deeply dissected Triassic sandstone bench. Sandy soils of high erosion class can be expected. Particular problems may occur on steep slopes at valley sides and heads, especially as long slopes are apparent. Remnant steep slopes at edge of Triassic sandstone and Permian Jackey Formation (sandstone) bench, approximately below the 750 m contour. Moderate to high erosion class if soils are sandy and thick. Moderate to low landslide risk unless deeply weathered and clayey. Lower areas underlain by Permian Bogan Gap Group siltstone have low erosion and low landslide risk unless deeply weathered.

BA 3. Deeply dissected. High proportion of area has steep long slopes. Some steep upper slopes on Triassic sandstone may have high erosion class due to sandy soils. Majority of slopes underlain by Permian Bogan Gap Group siltstone with low to moderate risk of erosion and landslide unless deeply weathered.

LR 1. Higher areas have locally steep slopes on dolerite talus with moderate landslide risk. The steep slopes at the edge of the Triassic sandstone bench below 720 m contour have sandy soils with potentially high erosion class. Steep lower slopes underlain by Permian Ferntree Mudstone have moderate to low erosion and low landslide risk unless deeply weathered.

WC 2. Major steep slopes are underlain by Quaternary gravel and Triassic sandstone. High erosion class on sandstone slopes. Quaternary gravels are similar to dolerite talus with moderate landslide and low erosion risk. Steep slopes between 600 m and 700 m underlain by Permian mudstone and sandstone. High erosion risk if soils are sandy. Moderate to low landslide risk unless deeply weathered.

LT 10. Major area of steep slopes underlain by Permian Ferntree Mudstone and Woodbridge Glacials. Low to moderate erosion and low landslide risk unless deeply weathered and sandy soils. Long steep slopes common.

HU 6. Steep upper slopes underlain by dolerite talus, Triassic sandstone and Permian Jackey Formation. Edge of major bench between 800 m and 600 m has high erosion potential due to sandy soils. Moderate to high landslide risk at talus fringe at edge of major bench. Moderate mid-slopes underlain by Permian Bogan Gap Group siltstone have low erosion and low landslide risk unless soils are sandy or deep weathered.

BS 11. Steep slopes, above approximately the 900 m contour, are underlain by dolerite talus with low erosion risk and moderate landslide risk, especially where the talus is thin at the edge of Permian rock benches. Minor areas of high erosion risk include steep and moderate slopes adjacent to streams and underlain by granodiorite.

LR 3. Minor areas of steep and moderate slope on dolerite talus and Permian Bogan Gap Group siltstone. Low erosion and low landslide risk unless deeply weathered. Highest landslide risk on steep slopes at talus fringe.

HU 7. Minor areas of steep and moderate slope are underlain by dolerite talus and Permian sediments. Low to moderate landslide and erosion risk unless soils are sandy. Higher landslide risk where talus veneer is thin, especially adjacent to Warners Creek in the southern part of the area.

LR 14. Minor steep slopes underlain by dolerite talus with low landslide and low erosion risk.

TU 11. Low erosion and low landslide risk.

LR 5. Low erosion and low landslide risk.

TU 3. Low erosion and low landslide risk.

TU 7. Low erosion and low landslide risk.

CONCLUSIONS

The aim of this report has been to provide a broad overview of potential geological hazards in areas of forest operations on the Great Western Tiers and South Barrow escarpments. These potential geological hazards include sheet, rill, gully and tunnel erosion, and landsliding. The hazard risk is considered to be closely related to the topography and geology. The topography strongly reflects the resistance to erosion of the underlying rock types. These concepts are considered to form the basis of the risk assessment, in terms of erosion and landsliding.

All rock types in the areas under investigation are subject to the landslide risk, depending on the steepness of slope, the presence and nature of the soil and weathered bedrock, and groundwater conditions. The slope criteria which should be used in assessments has been outlined in this report.

In summary, slopes greater than 20° (35%) have a very high potential for failure and erosion and should therefore remain undisturbed. Slopes between 15° and 20° (25% to 35%) are potentially unstable and should be treated with caution by modifying operations and careful planning. Slopes between 15° and 12° (21% to 25%) are known to have failed in some cases, particularly where roading has resulted in the excavation of steep embankments, and therefore consideration of this risk should be included in the assessment. Slopes below 12° (21%) are considered to be stable.

The soils and weathered bedrock in each area are all subject to erosion, to a varying extent. Accelerated erosion will occur after forest clearfelling, and operation planning and erosion control measures should be designed to minimise this. The potential erosion susceptibility of the various rock types has been discussed elsewhere in this report and slopes greater than 12° (21%) may be considered to be potentially sensitive.

Increased runoff can be expected for a period of approximately five years after forest clearfelling (Sloane 1983a). This increase is related to a reduction in rainfall infiltration, interception and evapotranspiration, compaction of soils, and alteration of drainage due to ground disturbance. The overall effect may result in accelerated erosion with an associated deterioration of water quality in adjacent streams through increasing the sediment yield. The Forestry Commission 'Guidelines' (1981) are designed to minimise these detrimental effects of forestry operations.

The main sources of erosion and sediment yield to streams are caused by ground disturbance, particularly from roads, access and snig tracks. Therefore the careful planning of roads and snig track systems is essential. Some suggestions include the

location of tracks along ridges or benches or at the base of slopes. Midslope or upper footslope locations are to be avoided wherever possible as these areas are sensitive to erosion. Uphill snagging is advised on moderate slopes, wherever practical, as the divergent pattern of tracks tends to disperse runoff.

Soil is the most important basic resource of the forest and soil conservation is highly important in order to minimise erosion and preserve the capacity of the area for reafforestation and further harvesting.

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[21 November 1986]

APPENDIX 1.

INSPECTION OF FORESTRY LANDSLIDE 'B' - GREAT WESTERN TIERS.

B.D. Weldon.

A landslide on the slopes of the Great Western Tiers was inspected with APPM representatives and several officers from the Forestry Commission on Wednesday 25 June 1986. A logging road traverses a 'bench' on the slopes of the Great Western Tiers. The landslide is located on the edge of this bench and is some 60 m north-east of the logging access road.

The landslide is relatively narrow (about 30 m across), affecting a long slope segment (estimated at 120-140 m long). Splash marks on trees adjacent to and within the path of the landslide mass indicate that the landslide was apparently quite fluid at the time of failure.

The surface geology consists of boulders of Jurassic age dolerite in a clayey matrix. These are talus deposits overlying the bedrock. Fragments of sandstone were observed within the landslide mass. Toward the north-western edge of the landslide, a large mass of Triassic age sandstone crops out. Green/blue, highly plastic clays were observed both above and below the sandstone mass.

The headscarp of the landslide is located within a natural drainage path which leads from the bench (variable slopes 4-10 degrees) to the steep slopes (16-22 degrees) of the Tiers. This natural drainage path is now fed with water collected by the roadside table drains. The Forestry and APPM personnel were concerned that this roadside water may have been a trigger for landsliding. This is probably the case. However, because the natural drainage path feeds the head scarp area of the landslide, it may merely have accelerated the occurrence of the landslide. Without the benefit of watershed mapping it is difficult to assess the role that roadside water played in initiating the landslide.

The slope on which the landslide has occurred is potentially unstable. Topographic maps show irregular contours, the slope is steep and landslides have occurred in the past. The geological setting of a dolerite veneer overlying Triassic sandstone is known to be unstable elsewhere in Tasmania.

After discussing the above mentioned points in the field, it was agreed that some guidelines were required to assist the foresters to identify areas where the local conditions were unfavourable with respect to slope stability.

FORESTRY AREAS - GREAT WESTERN TIERS AND MT BARROW
Slope classes and Geology.

LEGEND

Slope classes

	Greater than 20° (35%)
	Between 12° and 20° (21-35%)
	Less than 12° (21%)

Geology

QUATERNARY

	Qs	<i>Dolerite scree.</i>
	Qtd	<i>Dolerite talus.</i>
	Qg	<i>Talus and gravel 'rock glaciers'</i>

JURASSIC

	Jd	<i>Dolerite.</i>
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TRIASSIC

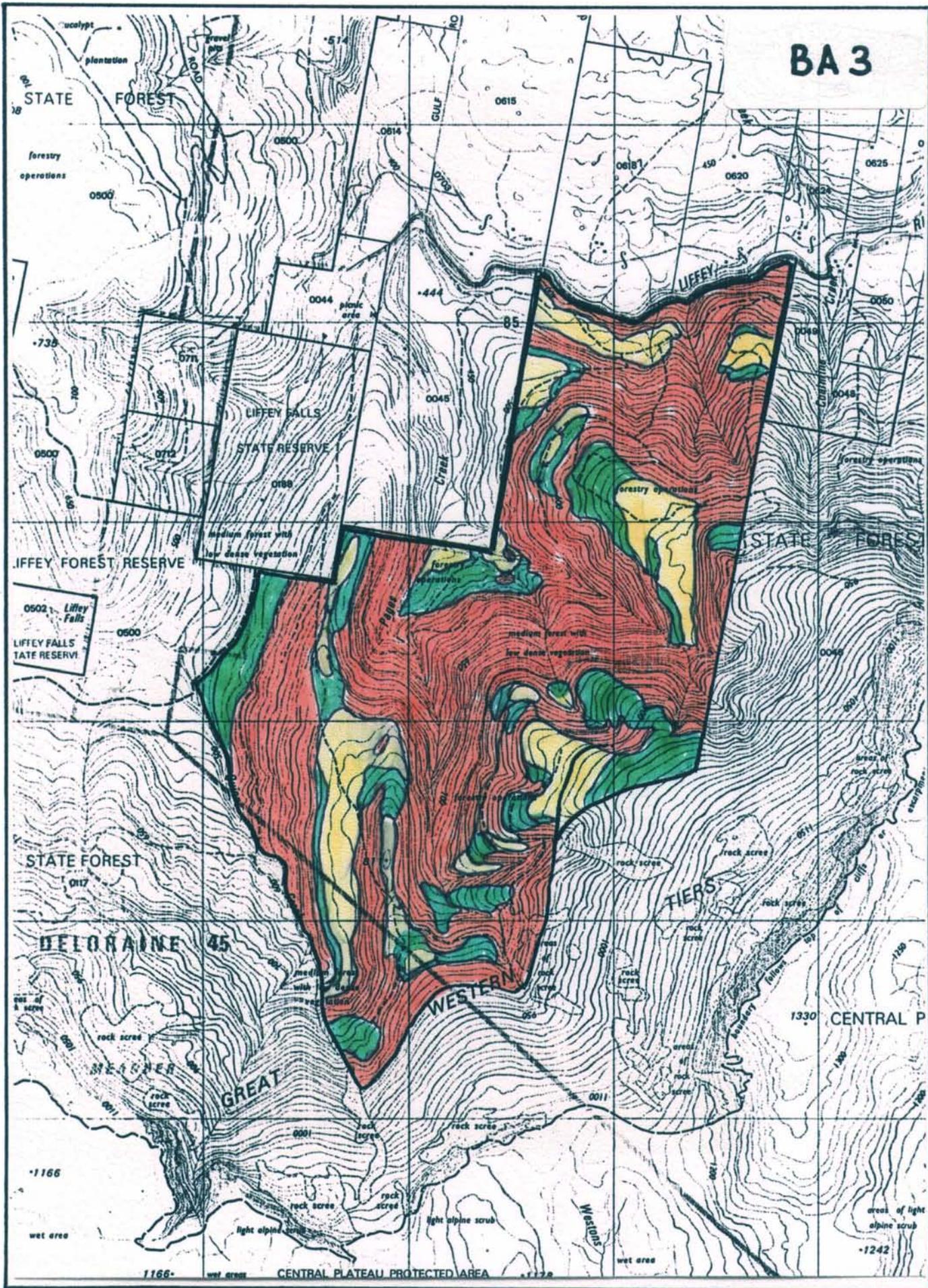
	Tr	<i>Sandstone, minor shale bands.</i>
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PERMIAN

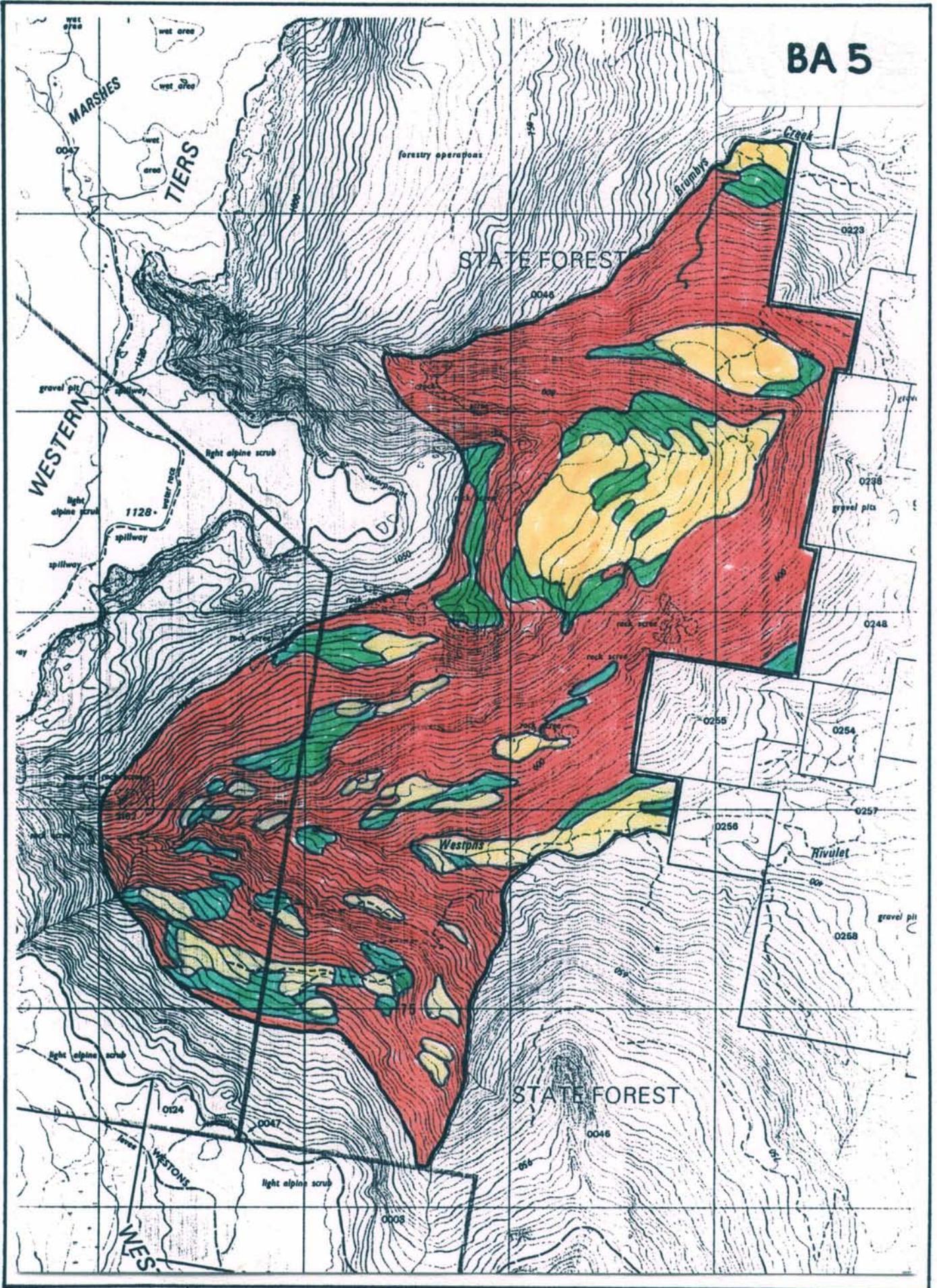
	Pj	<i>Jackey formation. Sandstone and shale.</i>
	Pb	<i>Bogan Gap Group. Siltstone, minor sandstone.</i>
	Pf	<i>Ferntree Mudstone.</i>
	Pw	<i>Woodbridge Glacials. Mudstone, minor sandstone.</i>
	Pp	<i>Poatina Group. Siltstone and sandstone.</i>
	P1	<i>Liffey Group. Sandstone.</i>
	Pq	<i>Quamby Mudstone.</i>
	Pkb	<i>Kansas Creek Beds. Siltstone, sandstone and conglomerate</i>
	Pm	<i>Lower Permian. Mudstone.</i>
	Pmc	<i>Lower Permian. Conglomerate.</i>

DEVONIAN

	Dg	<i>Granodiorite.</i>
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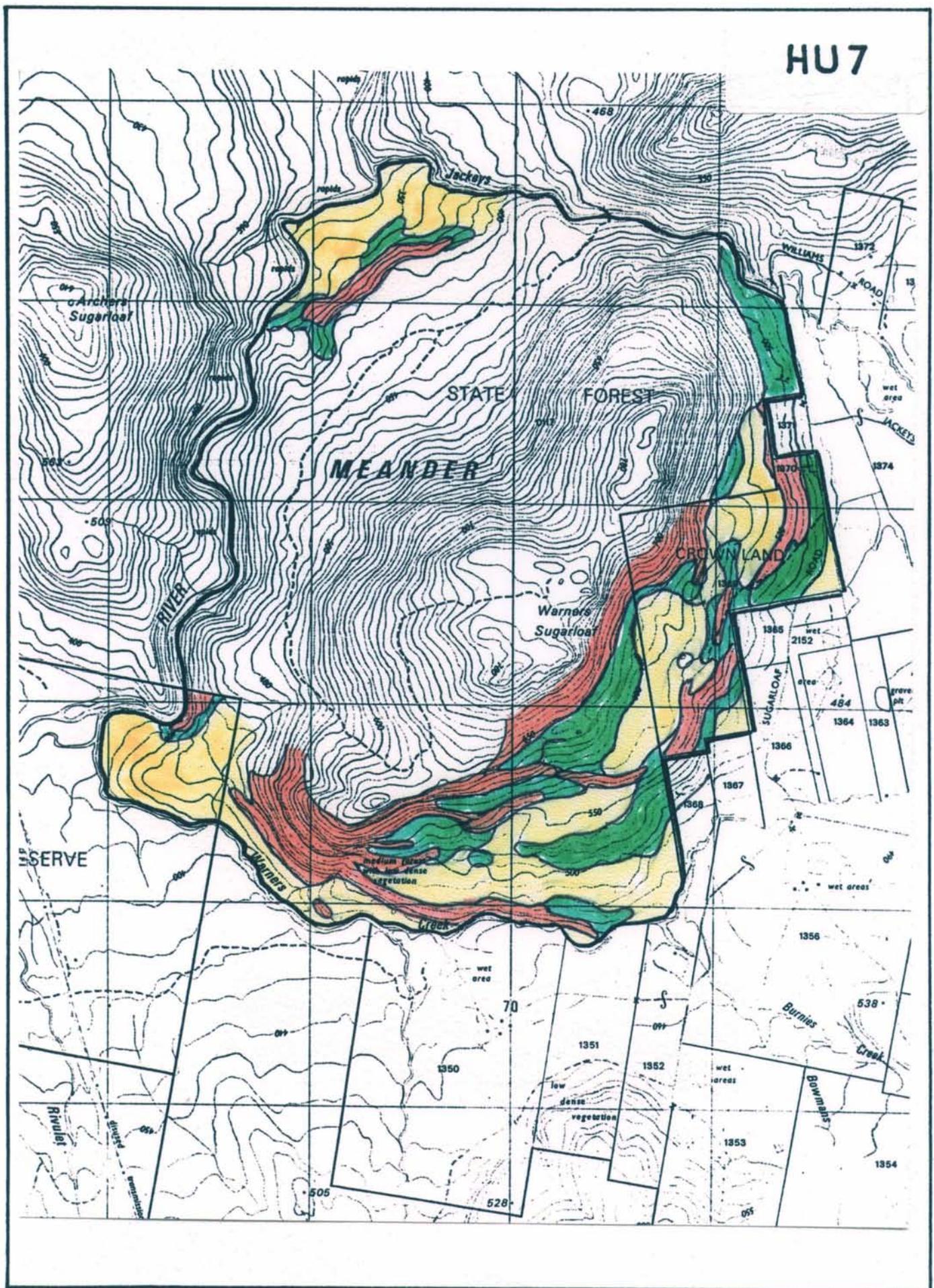


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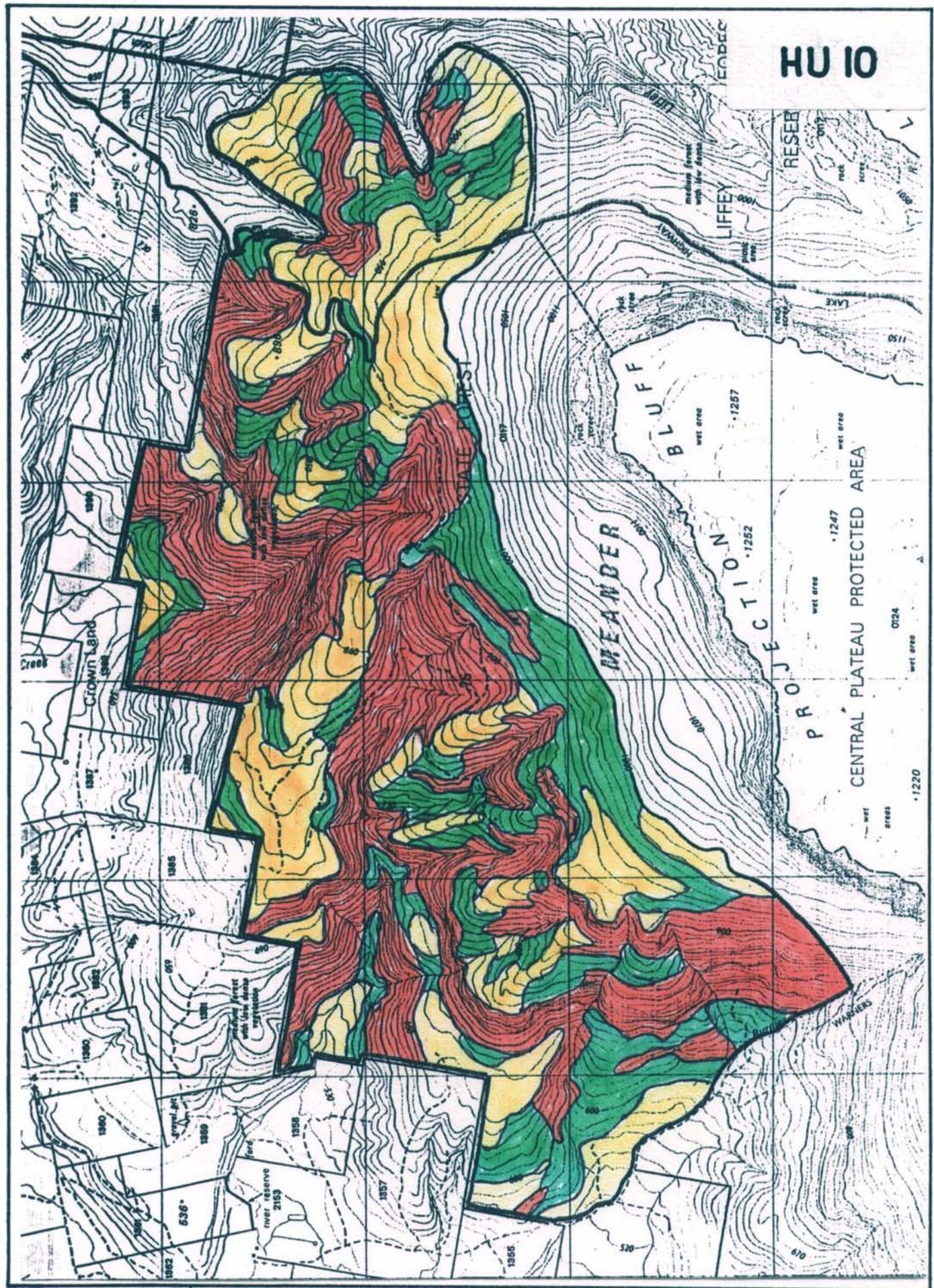
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HU7



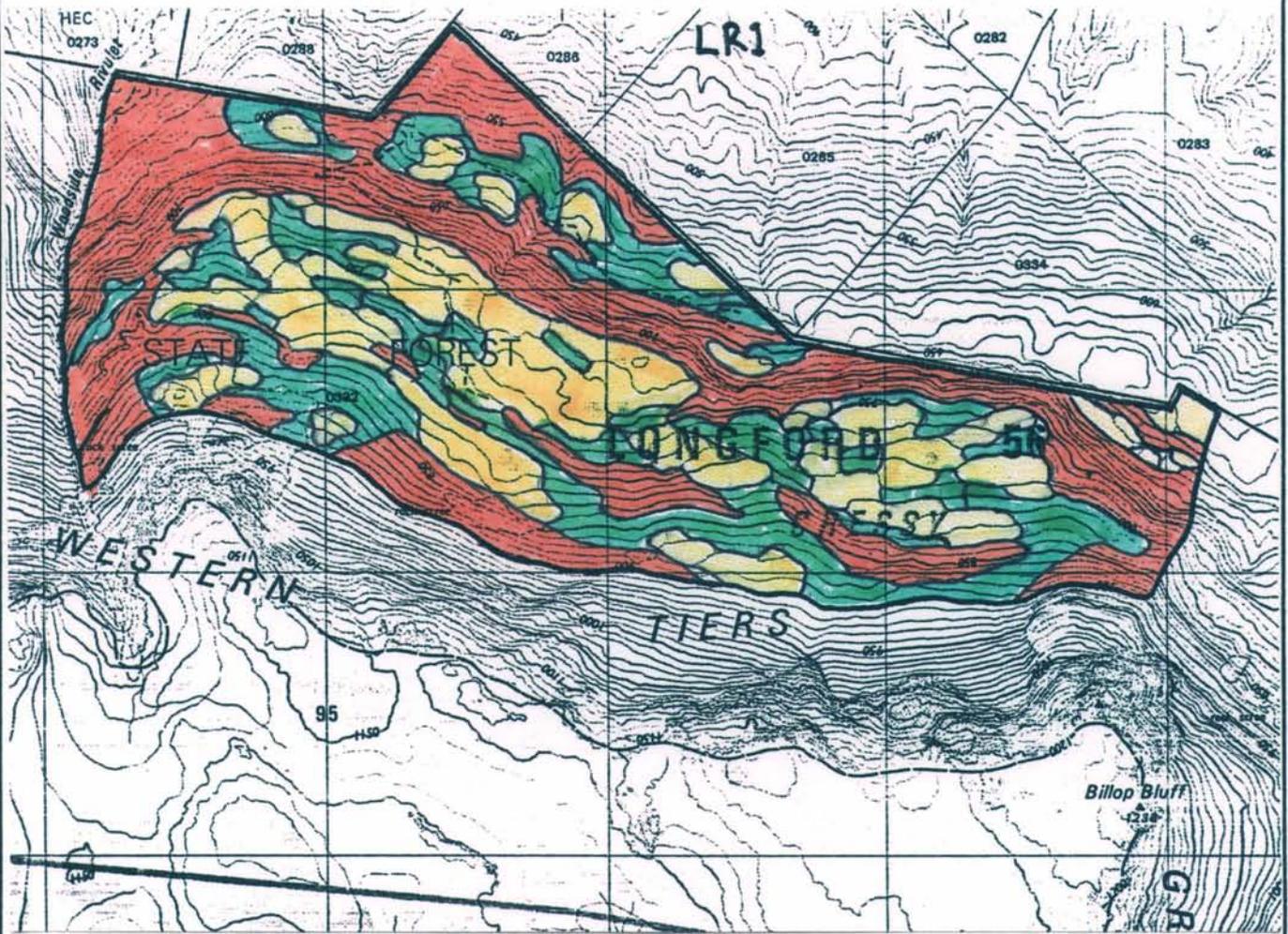
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HU 10



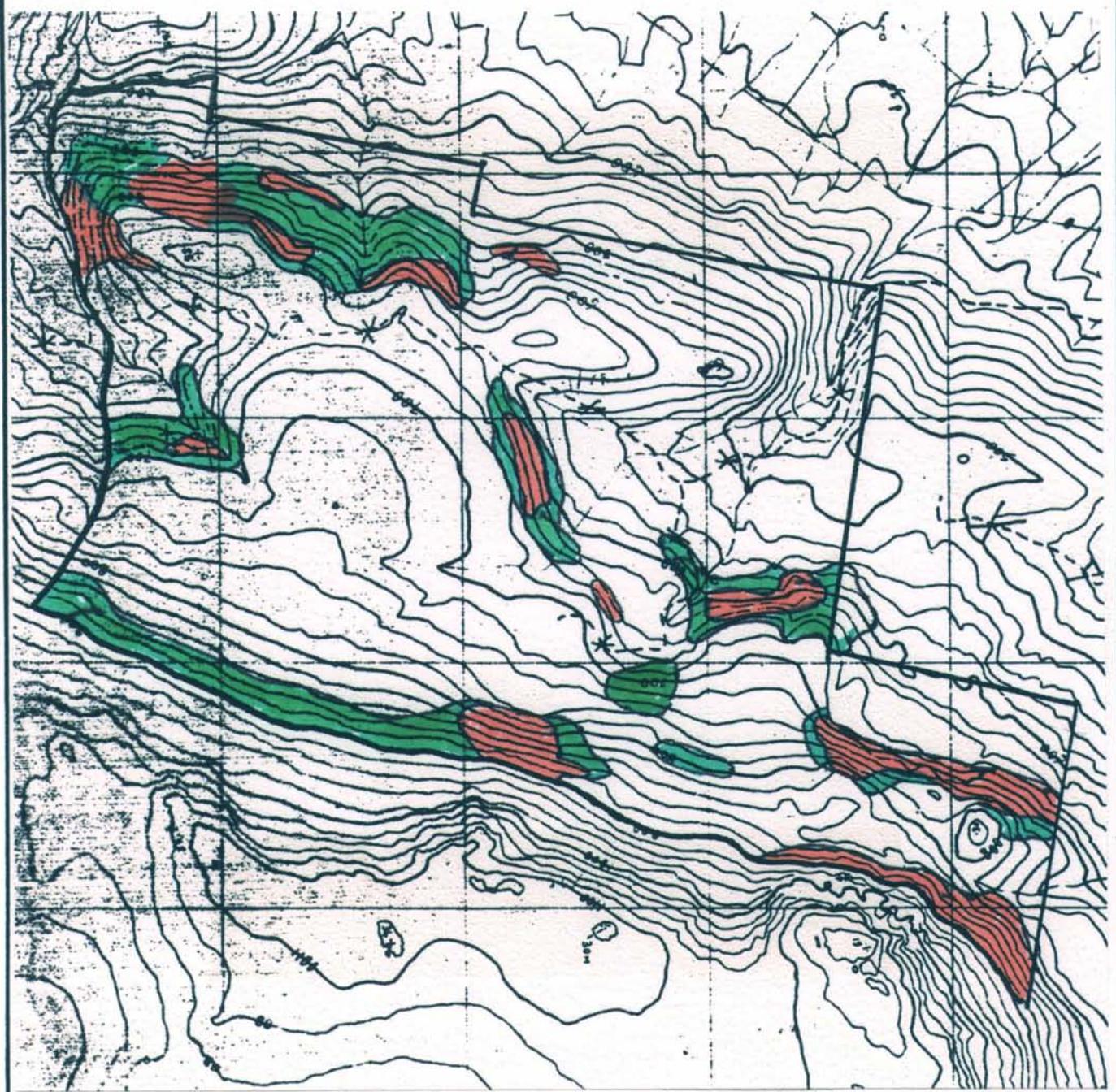
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LR1



5 cm

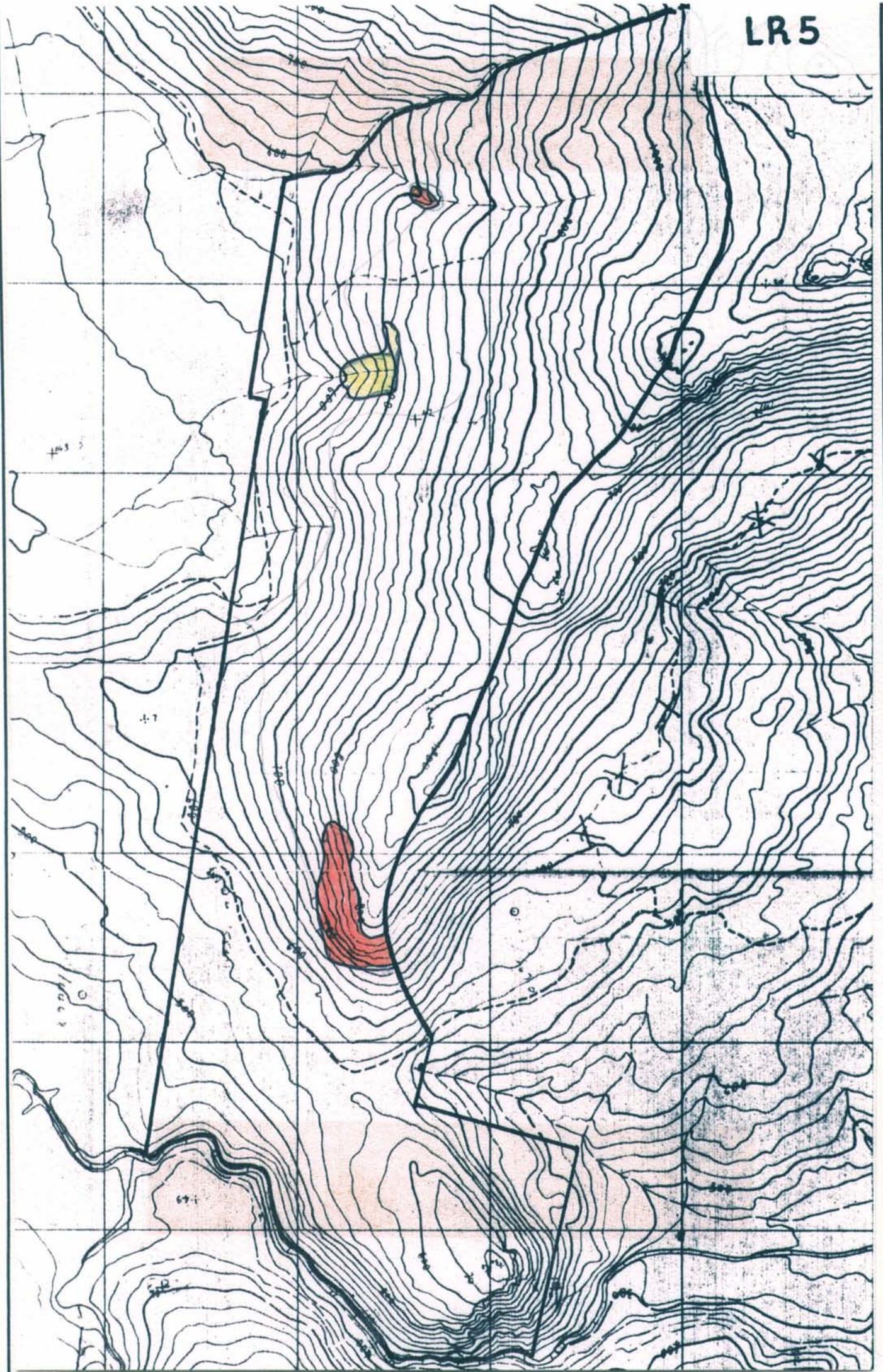
LR3



5 cm

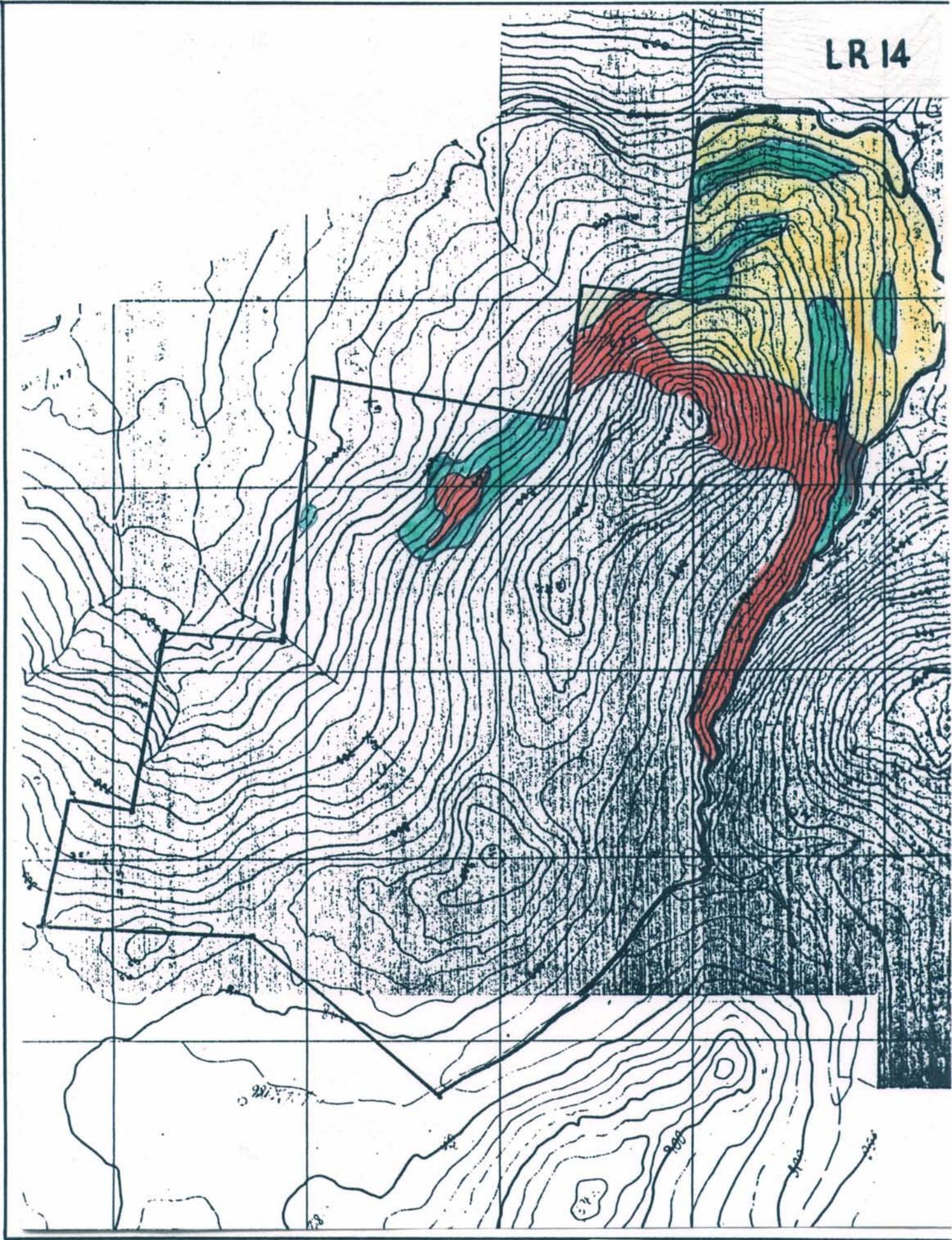
LR 5

28/34

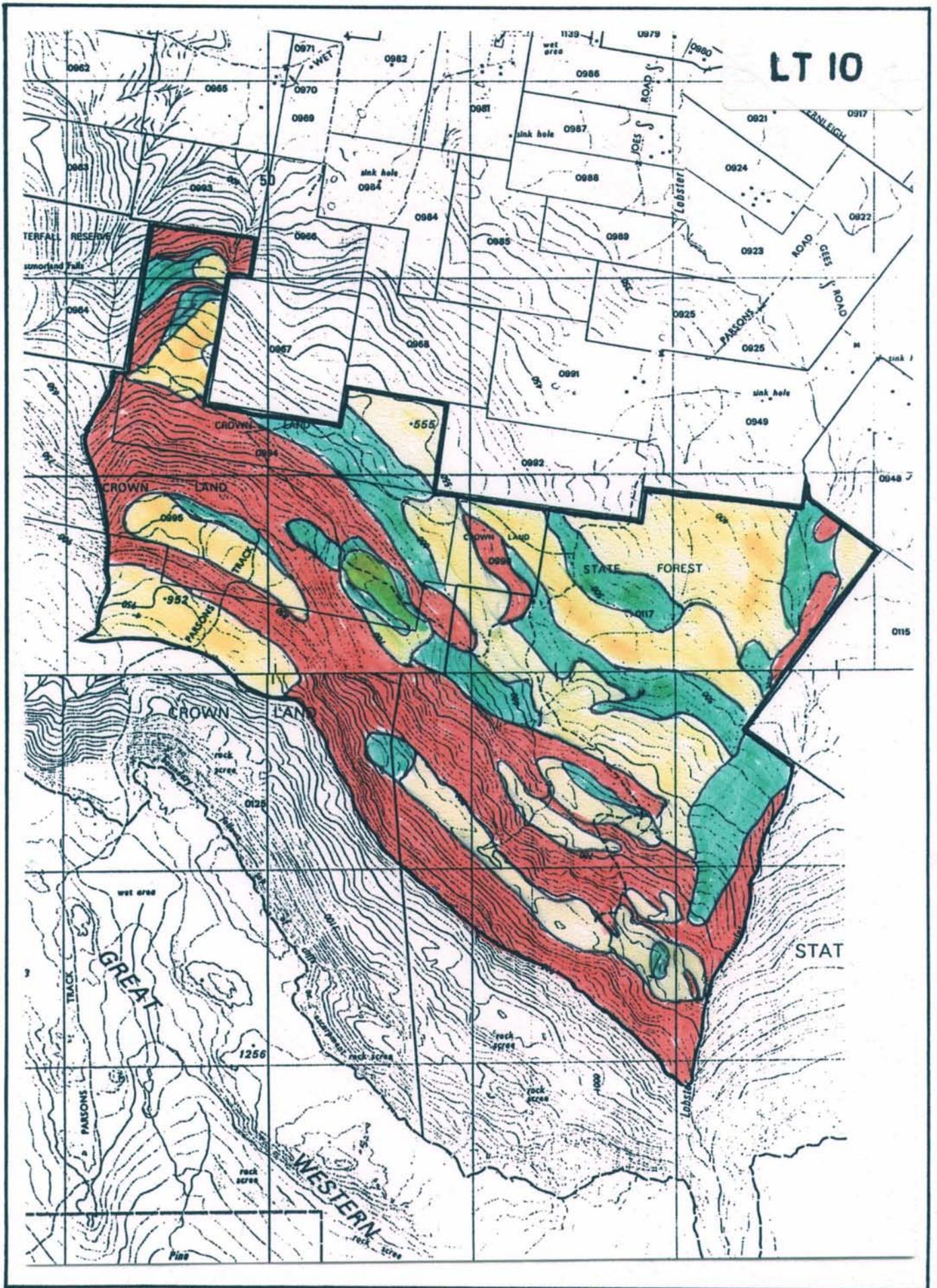


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LR 14



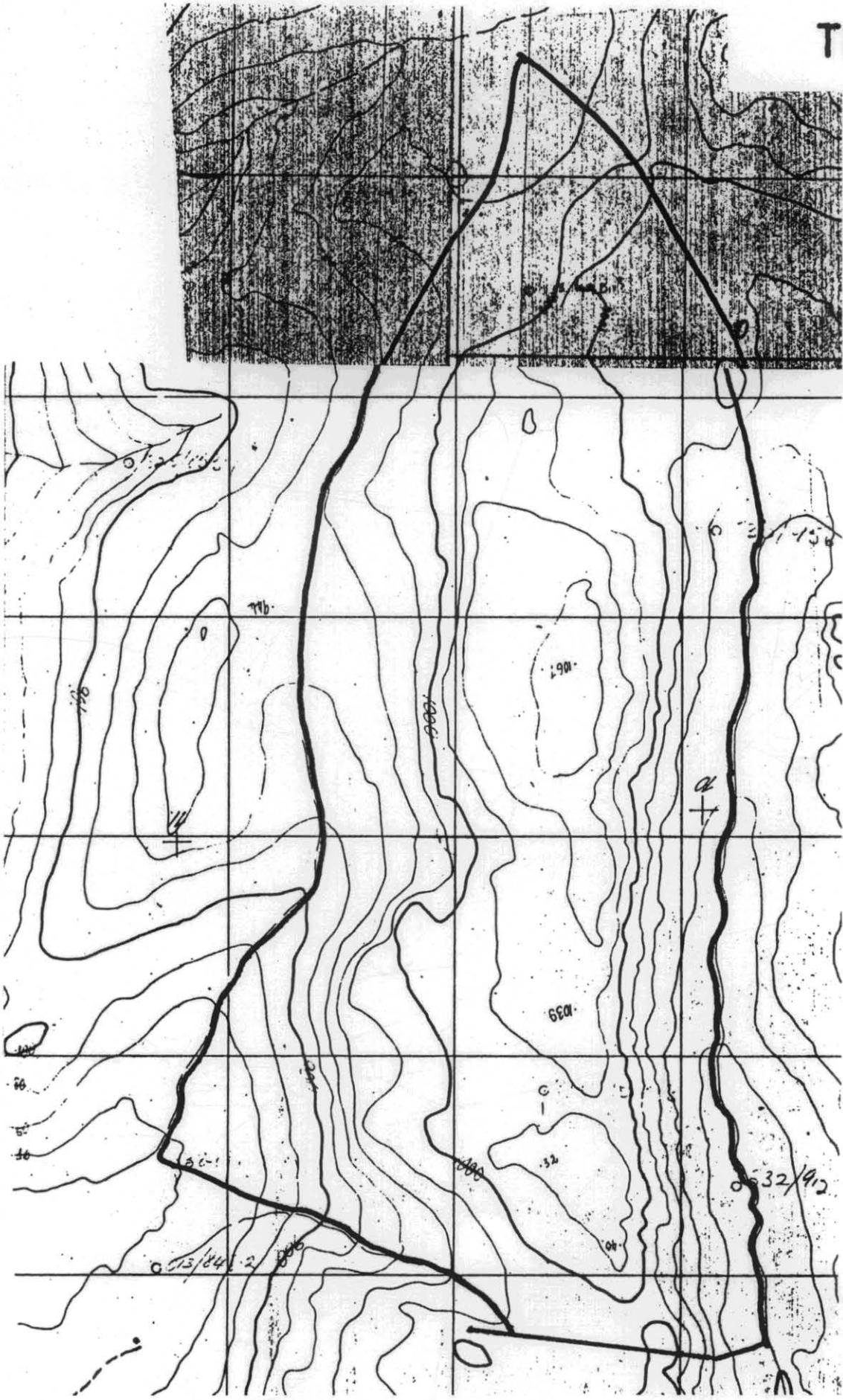
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LT 10

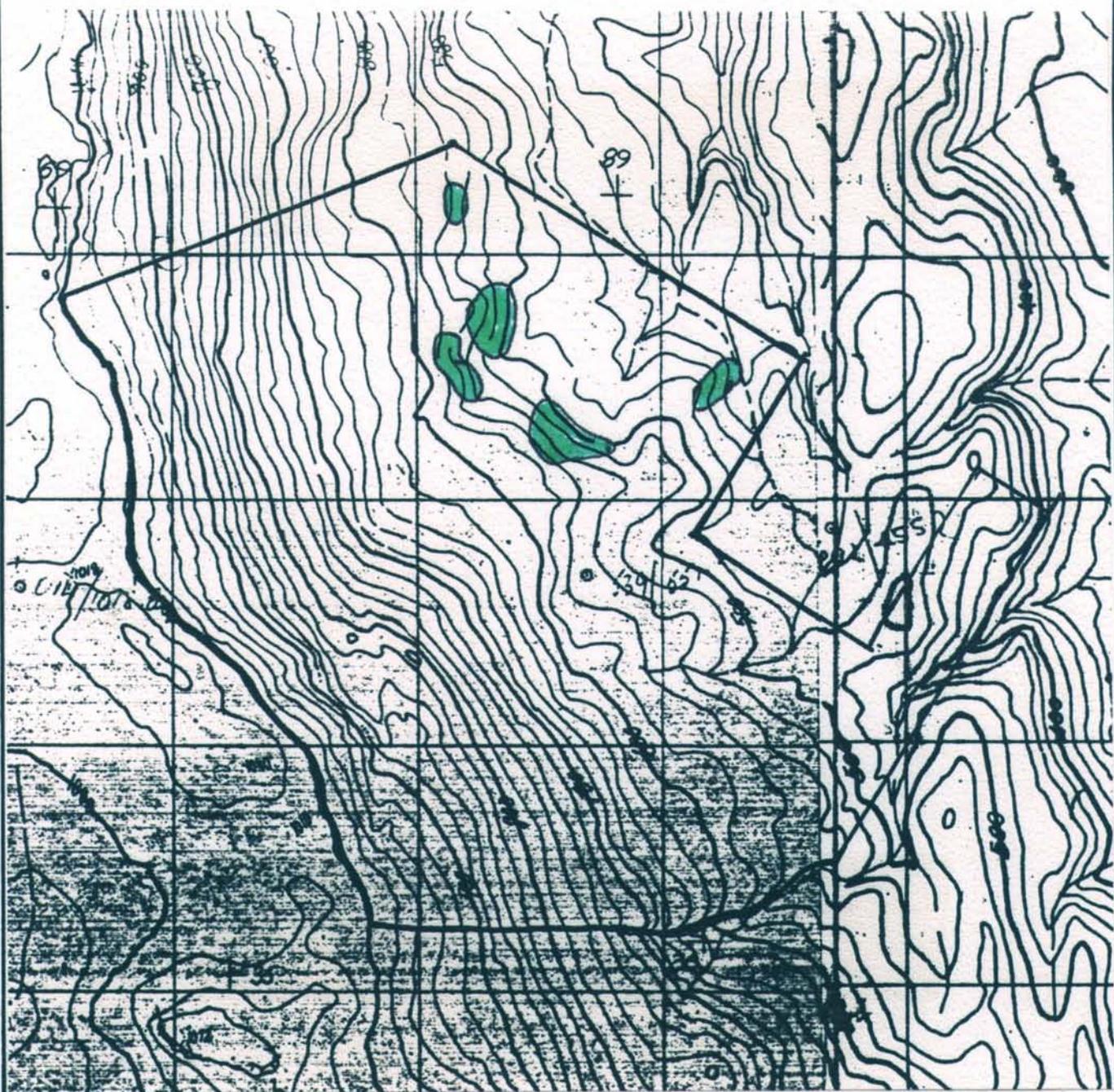
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TU7



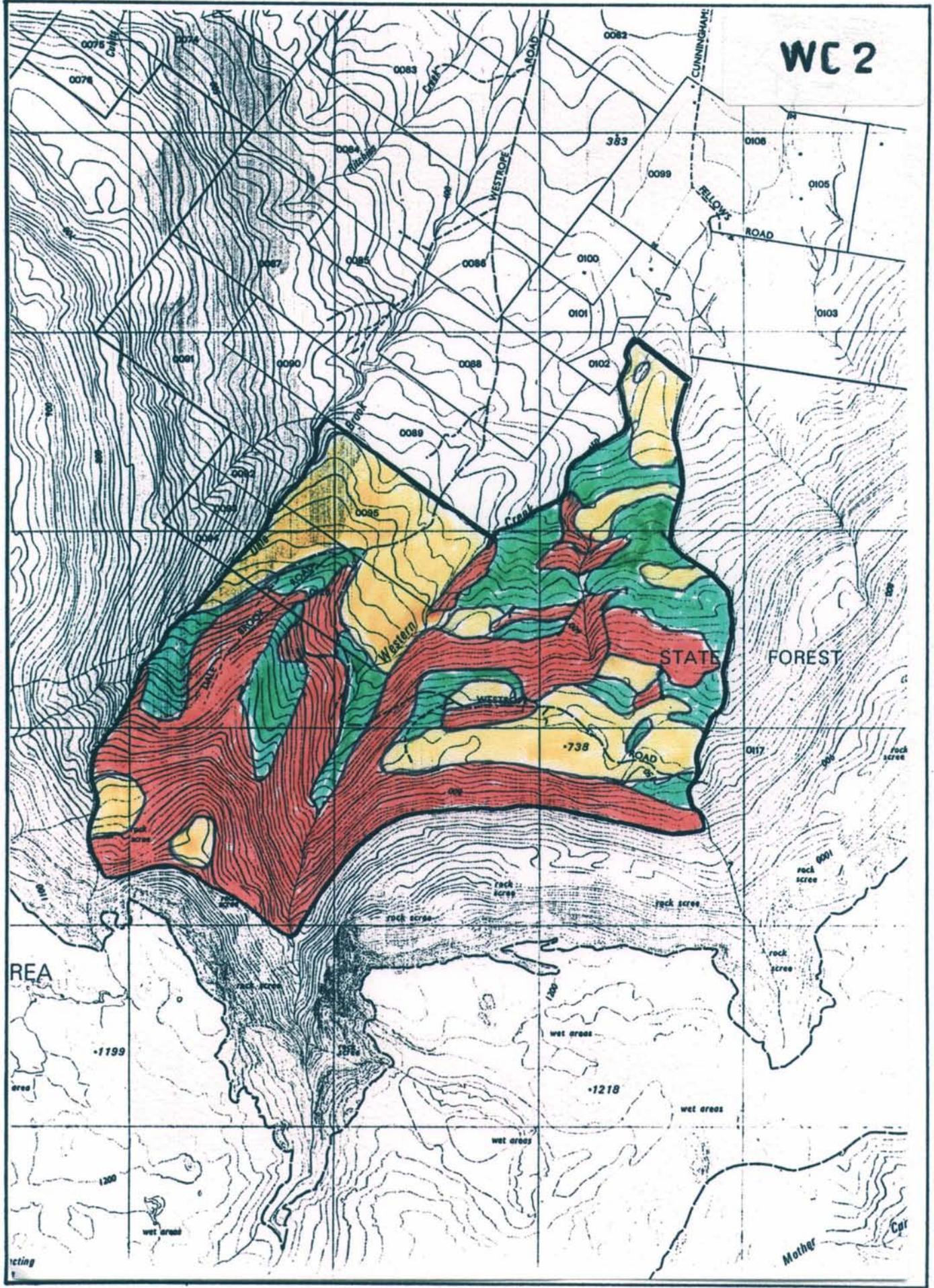
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TU II



5 cm

WC 2



5 cm