SUMMARY OF GEOLOGICAL, SOIL AND WATER INVESTIGATIONS IN THE KOONYA DISTRICT

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BACKGROUND

This report summarises the investigations into the potential impacts of forestry operations in the Mt Koonya area, Tasman Peninsula, Tasmania, on water yield and water quality, as initially proposed in the project proposal by McIntosh et al. (22 November 2002).

PREVIOUS RESEARCH

Sloane (1987)

The first of the several commissioned reports in the Mt Koonya area was that by Sloane (1987), and was chiefly concerned with the springs on the northern slopes of Mt Clark and slope instability problems. From limited field work Sloane concluded that “Some of the groundwater [feeding the springs on the northern slopes of Mt Clark] undoubtedly originates from rainfall infiltration on the plateau area to the south of the watershed”. Sloane reached this conclusion because he believed the constant flow of springs on the northern slopes of Mt Clark could not be sustained from the small catchment areas upslope of the seepages.

With some caveats Sloane predicted that the springs could dry up if clearfelling proceeded on Mt Clark and the forest was replaced with new, rapidly growing young trees. He did not specify what area of operations might produce this result, but implied that clearfelling the whole area might cause the springs to stop flowing. [Clearfelling of smaller areas would, of course, produce proportionally less effect. There is evidence that about 20% of a catchment has to be logged before any measurable difference in water yield is apparent (Vertessy 1999)].

With regard to slope instability, Sloane (1987) noted the existence of past landslide features on the dolerite-talus covered northern slopes of Mt Clark, at the northern end of Grooms Hill and at locations adjacent to the Nubeena Back Road. He recommended that steep talus-covered slopes should not be logged because of actual and potential slope stability problems. However, he considered that slopes underlain by *in-situ* dolerite were stable.

Weldon (1991)

The second commissioned report (Weldon 1991) examined the “Koonya block” which is that area, about 3 km wide in an east-west direction, between Fire Tower Road and the access road ascending from the quarry reserve in Newmans Creek (Figure 1).

Weldon summarised existing knowledge on fractured-rock aquifers in dolerite and supplemented literature findings with local observations. He considered that the springs in the Koonya area (east of Firetower Road) were supplied in the main from a fractured-rock aquifer (i.e. an aquifer in fractured dolerite) supplemented by lateral seepage above impermeable soil horizons or lateral seepage at the slope talus-bedrock interface. He noted that 50% of water samples from bores drilled into dolerite fractured-rock aquifers elsewhere had total dissolved solids (TDS) >1000 mg/L.

Weldon noted that water flow in talus deposits occurs through subsurface conduits, particularly where soils are dispersive. Noting the turbidity in some of the Koonya springs, he remarked "it is possible that some turbidity observed at springs in the Koonya area is a result of this [dispersion] process".

Weldon's other conclusions were as follows:

1. "Forestry operations east of the ridge line [Mt Koonya to Kingstons Pinnacle] are assessed as having only a remote probability of affecting the spring water quality and quantity."
2. "It is considered that any component of spring water derived from a fractured-rock aquifer system will be unaffected in quality by forestry operations east of the Mt Koonya ridge line. The ridge is some 500 m distant from the nearest known spring and any suspended load entering the aquifer in the logging area should have settled out before reaching the spring."
3. "[Restriction of forestry operations to the area east of the Mt Koonya divide] will preserve the quality of spring water derived from infiltration through the talus slope deposit (i.e. near-surface groundwater) on the west side of the divide."
4. "It is considered that the suggestion by the Commission to restrict the area of forestry operations to a small percentage per annum of the total area of the "plateau", in combination with a forestry practice of thinning with some clearfelling, will not impact on groundwater quantity issuing from the springs."
5. "The Commission's proposed forestry management guidelines for the Koonya block are well reasoned. It is a cautious approach which should minimise the effect on stream and spring quality as well as slope instability. In reality, the effect is expected to be negligible."

Leaman (1999)
The report of Leaman (1999) was not commissioned but was made available by some residents of the area who sought Leaman's advice on how modification of a catchment might affect community water supplies. The report is based on Leaman's general knowledge of the area and some brief inspections, and presents general conclusions only. Among the statements in Leaman's report were the following:

1. Soils on dolerite tend to be clay rich, quite thin, very patchy, and rarely more than 200 mm thick.
2. Sandy soils tend to repel water until saturated which restricts input from showers.
3. Disturbance of the clay-rich dolerite or talus soils leads to a mixing and binding textural change which seals the surface and repels absorption. Run off is then maximised.
4. Loss of vegetation causes increased evaporation and loss of volume available for input to storage.
5. Research suggests that fire retards forest growth by several years.
6. Fire is not good forest practice.
7. Blockages are most serious within the dolerite and may lead to complete loss of flow and, rarely, catastrophic short-term flows upon clearance.
8. The observations in the report have "universal validity".

Statement 1 is only partly true: soils in dolerite in the Koonya study area are clay rich but mostly >75 cm thick and commonly >1 m thick (Davies and McIntosh 2003). While statement 2 is undoubtedly true for some sandy soils, especially dunesands subject to extreme summer drought, the effect has not be shown around Koonya and in any case will be insignificant on the forested Koonya uplands which are dominated by clayey soils formed in dolerite. Disturbance and passes with machinery (statement 3) can lead to compaction and surface sealing on roads but this effect was not observed on harvested land (other than on main tracks) either on the Giblin coupe or on carefully harvested (matted and corded) areas near Newmans Creek (McIntosh 1999, 2002a). In regard to statement 4 it is well established that forest harvest does not cause evapotranspiration to increase (as stated by Leaman 1999) but causes it to *decrease*. Consequently for several years after harvest increased streamflow can be expected from increased deep infiltration or increased surface runoff or both, depending on soil water-holding capacity (Vertessy 1999).

In regard to statements 6 and 7 it is well-established that in wet sclerophyll forest fire promotes forest regeneration (Mount 1964). Blockages and catastrophic flows resulting from forestry operations on soils in dolerite (statement 7) have not been reported in the Koonya district, nor have any instances been reported to the Forest Practices Board in the period 1999–2003.

Leaman (1999) concluded that both a detailed survey of the area's geology and hydrology, and long-term monitoring, was required before forestry operations proceeded further.

McIntosh (1999)

McIntosh (1999) reported on field observations made during a reconnaissance of the effects of forest operations on soils and water. Thinning in a coupe east of Newmans Creek was observed to have minimal impact on soils, because of the effectiveness of slash cover (matting) on snig tracks in preventing contact between machinery and soils. Parsons Bay Creek (south of Mt Koonya) was observed to be cloudy because it drains a mainly agricultural catchment. Mr Noye, who farms the slopes on the southwest of Mt Clark, mentioned that all except one of the springs on the west or southwest slopes of his farm run dry in summer, confirming that most subsurface drainage is towards the northeast, following the inferred inclination of the dolerite-sedimentary rock contact (McIntosh et al. 2002) and supporting Sloane's (1987) conclusions regarding sources of water for the northern Mt Clark springs.

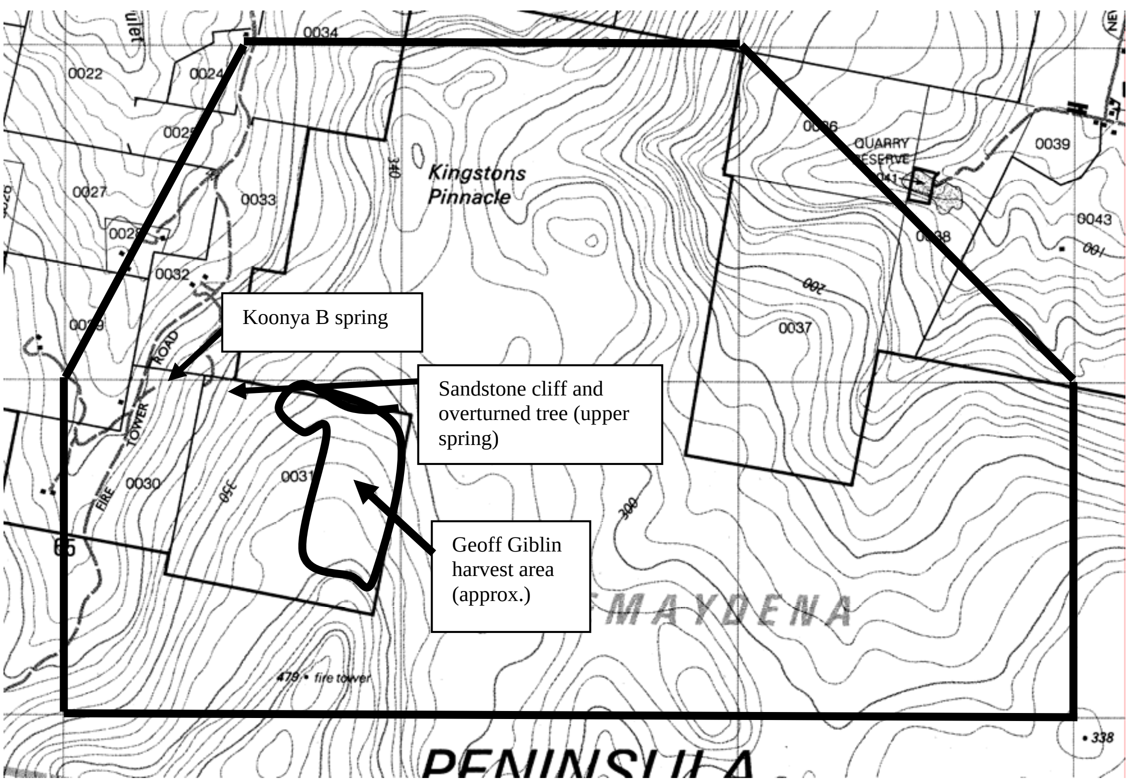

Figure 1. Outline of study area and location of the Koonya B spring and water sampling site.

McIntosh (2002a)
On 1 August 2002 P. McIntosh (FPB), T. O'Malley (consultant) and H. Cusick (Gunns Ltd) visited the Geoff Giblin coupe to assess soil disturbance and its possible influence on the water quality of streams and springs near Firetower Road (McIntosh 2002a). The harvested area of the coupe was confined to the rolling land in the east of the block and was underlain by deep soils in weathered dolerite. There was no evidence of surface flow of soil material except some slight movement on tracks. Eucalypt regeneration was poor, but vegetation cover was good. Geoff Giblin's hut on the property was beside a stream which was running clear, as was a spring at AGD map reference 565517 5227853 at the 'sandstone cliff' (which was later confirmed to be a source of water reaching Koonya B at lower altitude (McIntosh and Hayward 2003)). Instability was noted on lower slopes undisturbed by logging.

McIntosh (2002b)
McIntosh (2002b) summarised a field meeting that observed the condition of streams and springs along Firetower Road on 20 August 2002. Five streams or springs were looked at and all except one originating on B. Tooker's property were running cloudy. Surface flow from the unmetalled Firetower Road was observed to be a source of silt entering into Cascade Rivulet, which runs parallel to the road.

RECENT RESEARCH

Geology (Forsyth 2003)
Within the study area as defined in Figure 1, the rocks are subhorizontal, thus the oldest rocks are found in the lowest landscape positions, for example near the stream in the Cascade Creek valley, along which Firetower Road runs. The rocks are briefly described below, beginning with the oldest and deepest.

Triassic siltstone (Rqm)
The oldest rocks in the Mt Koonya district are interbedded siltstone, shale, sandstone and mudstone (Rqm) of Early Triassic age.

Triassic sandstone with quartz pebbles (Rvvp)
This formation is visible in places as an outcrop of sandstone several metres thick, containing pebbles and coarse sands of milky quartz. This is the hard unit forming a sandstone cliff above the Koonya B spring.

Triassic quartz-rich sandstone and mudstone (Rvv)
This formation occurs above the Rvvp formation. Outcrops can be seen on the track leading to G. Giblin's cottage. Mica and abundant carbonaceous fragmentary plant fossils occur on some sandstone bedding planes.

Jurassic Dolerite (Jd)
Intruded into the above rocks, and now capping them, are sheets (sills) of Jurassic dolerite, which are the results of one or more intrusions. Forsyth suggested that the dolerite sheet forming Mt Koonya is underlain in part by another (possibly younger) sheet extending northwards almost to the coast.

Quaternary deposits
The most significant Quaternary deposits are dolerite talus, which probably formed mainly as coarse scree during the Last Glacial (before 10 000 years B.P.), but may be in part the result of later instability, including large landslides. The dolerite talus commonly mantles the older sedimentary rocks.

Landslides

Two landslides have been identified on the G. Giblin property and two others on the steep westerly aspect slopes east of Fire Tower Road. All four landslides occur in dolerite talus and the slip planes are likely to be the contact of the dolerite talus and the underlying sedimentary rocks.

Hydrogeology

Forsyth (2003) deduced that the dolerite sheet east of Firetower Road had an overall dip of a few degrees to the east. He reasoned that a deep fractured-rock aquifer may exist within the dolerite rocks that overlie the sedimentary sequence. The "piezometric surface" or top of such an aquifer is likely to be convex and hence the aquifer could feed springs to the west as well as springs to the east (Figure 3). Fault zones running northwest to southeast are also likely to intercept the aquifer and direct a portion of the subsurface flow in a northwest direction rather than eastwards. The stream flowing east of Kingston's Pinnacle (Figure 1) and utilised by the Clark and Campbell Farms north of the study area may gain "extra" water by such fault control.

Forsyth (2003) pointed out that "fresh dolerite outcrops are commonly separated by extremely weathered dolerite that has retained traces of the igneous texture and joint surfaces" (Forsyth 2003, p. 24). This observation is supported by observations in quarries which indicate that the dolerite rock is penetrated by highly fractured and weathered zones. These weathered fracture zones range from 1.5 m across to 1 cm across (Figure 2). The weathered fracture zones are not open and water movement in these fracture zones is likely to be by unsaturated (capillary) flow. Saturated flow may occur in unweathered (younger) fractures.

Figure 2. Weathered fracture zones in dolerite. These weathered fracture zones are likely to be important infiltration pathways for moisture. The zones range from >1 m to 1 cm wide.

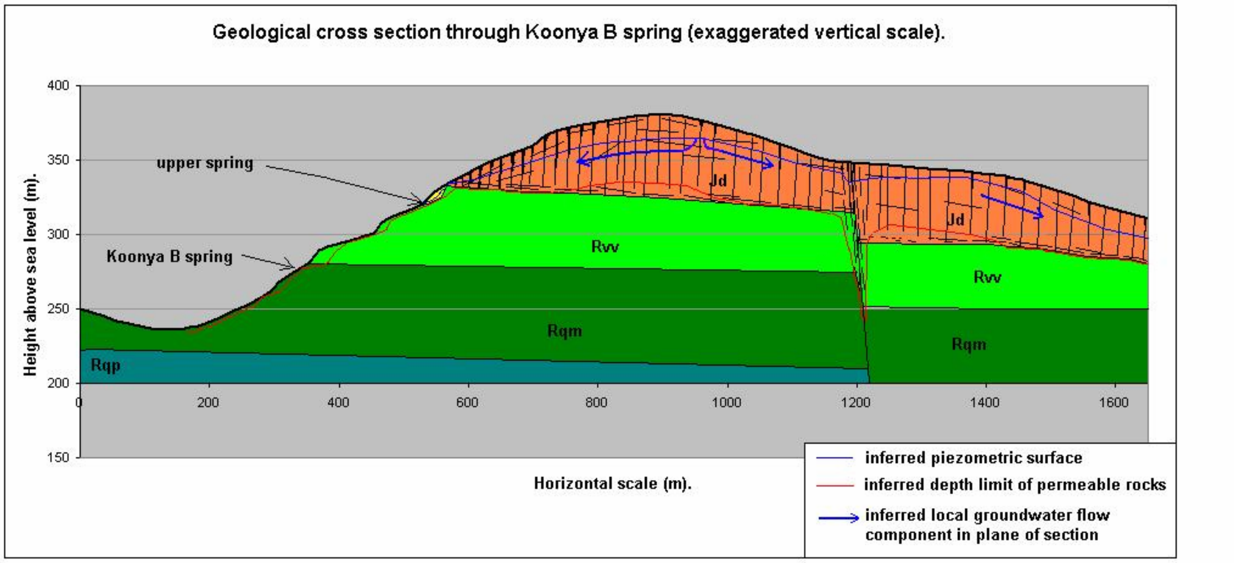

Figure 3. West to east (left to right) geological cross-section through the Koonya B sampling site, the sandstone cliff (marked as "upper spring") and the inferred aquifer in dolerite. Note the fault line which may direct some drainage in a northerly direction. Note also the dolerite contact with the sedimentary beds below is inclined eastwards, but that because of the likely convex shape of the aquifer surface, some subsurface water flow is westwards. From Forsyth (2003, figure 12).

Soils (Davies and McIntosh 2003)

Davies and McIntosh (2003) recognised eight soils in the study area. The soils formed in dolerite are the only soils likely to be directly affected by forestry activities. Both these soils are well-drained, have low or moderate erodibility, and are provisionally classified as either Ferrosols or Dermosols (Soils 1 and 2 in Davies and McIntosh (2003)). Wide experience with operations on these soils show that they are resistant to disturbance (Grant et al. 1995) and operations conforming to the Forest Practices Code (Forest Practices Board 2000) are unlikely to cause significant compaction.

Other soils are developed in siltstone/mudstone, in sandstone, or in mixed siltstone/mudstone/dolerite alluvium or colluvium. Most of these soils cover small areas on private blocks on which forestry operations are not planned. Of significance for the residents' water supply is the presence of imperfectly drained soils in mixed siltstone/mudstone/dolerite alluvium on a bench immediately upstream of the Koonya B spring. The stream feeding the spring flows through these soils and Davies and McIntosh (2003) concluded that: "The stream feeding the Koonya B spring flows through an area of tunnel gully erosion in soil 7, which is an imperfectly drained soil with silty clay texture, and has moderate to high erodibility. There is evidence that this soil material has periodically collapsed into the stream channel, probably during periods of high rainfall and water flow."

The absence of small streams on in-situ dolerite within the study area, and the absence of gley mottles within the soil profiles formed in dolerite, indicate the good drainage of these soils, which promotes deep infiltration. It should be noted that the upper horizons of soils in dolerite are well structured and do not have pans of low permeability. Consequently they will be very seldom above field capacity, surface runoff is minimal and water flowing through the soils will flow chiefly by capillary action rather than by turbulent mass movement through large pores, except after very heavy rainfall. During capillary (unsaturated) flow suspended silt, clay and organic matter will be filtered and deposited in micropores.

Water quality monitoring (McIntosh and Hayward 2003)
Forestry Tasmania has been recording water quality (Table 1) at a site named Koonya B since Febraury 1994. Analyses show no consistent trends since water quality monitoring began (Table 1). For example, most turbidity readings have been in the range 10 – 20 NTU, with occasional higher and lower values. Inspection of the Giblin coupe did not reveal significant erosion or compaction and there was no evidence that forest harvest had affected stream quality or water quality at the Koonya B sampling site.

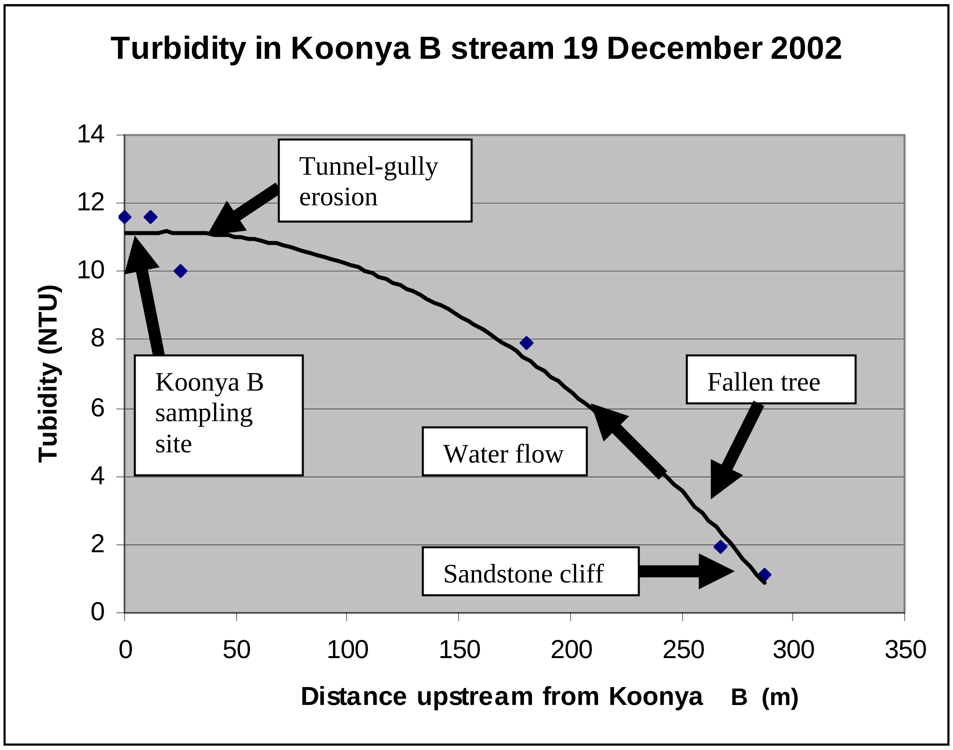

Figure 4. Mean turbidity levels (diamond symbols) at the Koonya B sampling site and at five points upstream, 19 December 2002.

There was strong evidence that soil disturbed by a naturally fallen tree was affecting water quality and in addition tunnel-gully erosion of silty soils of moderate to high erodibility upstream of the Koonya B sampling site is likely to have caused silt to enter the Koonya B stream (Figure 4).

Table 1. Water quality at the Koonya B sampling site.

Date	Colour (CU)	pH	TDS (mg/L)	TSS (mg/L)	Turbidity (NTU)
9 Feb 1994	-	-	-	-	4
9 May 1994	30	8.8	270	9	11
11 Jul 1994	40	8.0	250	13	16
31 Aug 1994	20	7.8	280	4	7
28 Nov 1994	85	7.5	255	6	15
6 Feb 1995	40	7.9	290	15	14
6 Apr 1995	20	7.7	280	3	3
23 Jun 1995	125	6.6	260	22	27
27 Sep 1995	50	7.7	265	12	13
21 Nov 1995	125	7.2	255	14	20
27 Feb 1996	30	8.1	275	15	5
20 May 1996	30	7.0	305	10	11
22 Jul 1996	50	7.4	280	17	16
18 Sep 1996	30	7.8	305	13	14
5 Feb 1997	100	7.5	300	14	21
6 May 1997	50	8.0	260	46	20
16 July 1997	40	7.8	275	12	12
29 Sep 1997	300	6.5	225	52	63
2 Dec 1997	50	7.9	280	14	12
12 Feb 1998	30	6.5	270	18	17
6 May 1998	20	7.6	260	14	13
30 Jul 1998	30	7.2	280	?	9
23 Dec 1998	5	8.0	280	20	11
8 Apr 1999	175	7.4	270	20	38
26 Aug 1999	50	7.9	290	10	16
20 Sep 1999	50	8.0	290	20	16
15 Mar 2000	30	8.1	250	20	15
8 May 2000	50	7.8	286	16	16
25 Jul 2000	60	7.7	286	12	12
5 Aug 2000	50	7.8	286	16	16
29 Sep 2000	40	7.5	284	13.	13
19 Nov 2000	70	7.5	264	21	20
11 May 2001	40	8.1	270	12.	12
12 Nov 2001	40	8.3	280	7	10
7 Feb 2002	30	8	272	9	8
26 Sep 2002	1	7.3	249	14	5
19 Dec 2002	-	-	-	-	11

Water quantity effects (McIntosh 2003)

McIntosh (2003) used long-term data from experimental clearfelling of Victorian forests to estimate the effects of harvest on deep infiltration into a subsurface aquifer, which was estimated to cover an area of 2.5 km^2 (Figure 5). Five coupes on the Koonya uplands were assumed, with each coupe 78% harvested, and harvest on any coupe separated from harvest on the next scheduled coupe by five years. He concluded that “the predicted effect of harvest on water yields relative to those at present (2003) is for yields to increase by an average of 23% for years 1–29 after harvest and then to fall to levels approximately equal to those at present for the next 40 years.”

McIntosh (2003) also considered an alternative model which assumed that the stream feeding the Koonya B spring is sourced, not from a large subsurface aquifer but from a c. 60 ha catchment that extends up to the Mt Koonya – Kingston Pinnacle divide and slightly beyond it. Taking into account the estimated effects of the 1998 harvest of forest on the Giblin block, the effect of a further 14.5 ha of harvest east of the divide but adjacent to the Giblin block was modelled. It was found that, provided harvest began no earlier than 2008, the effect of this additional harvest would be initially to raise water yields at the Koonya spring, then there would be a period in which mean annual water yield would be similar to that before harvest on the Giblin block, followed by a period of gradually increasing water yields (Figure 6).

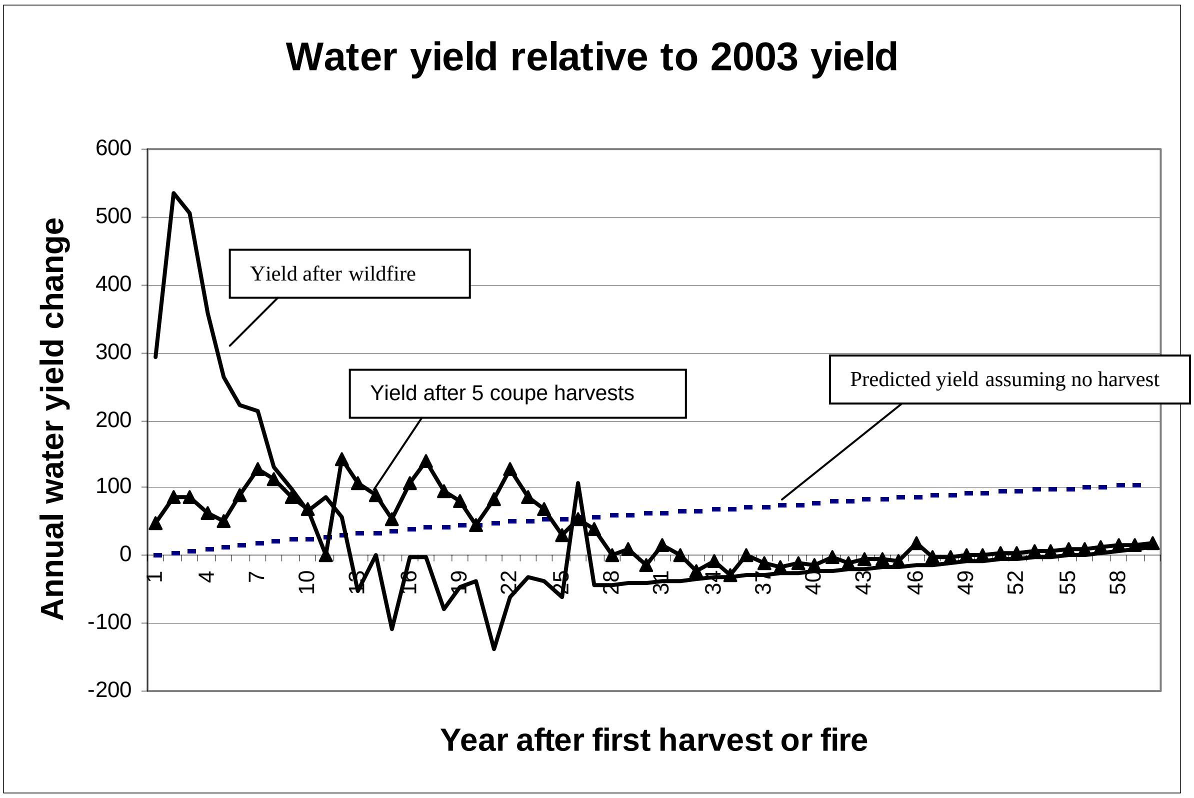

Figure 5. Predicted water yield after five coupe harvests, relative to water yield in 2003. (From McIntosh 2003.)

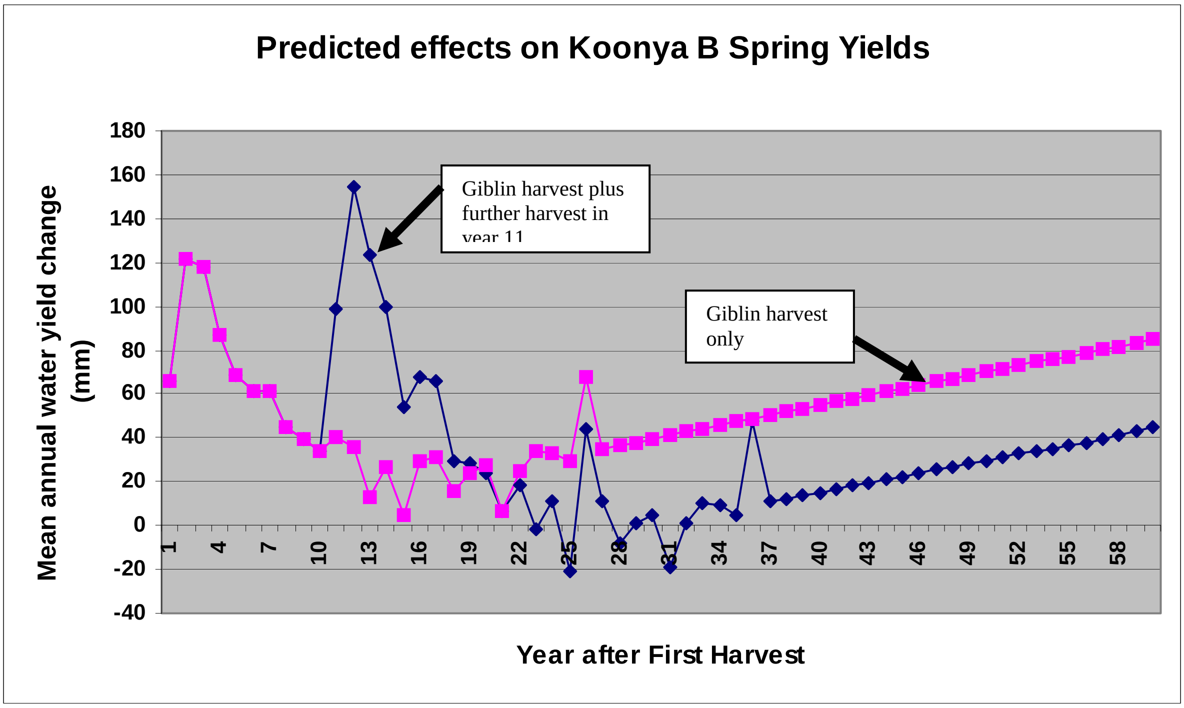

Figure 6. Predicted water yields relative to 1998 yield as a result of harvest on the Giblin coupe (diamond symbols) and as a result of harvest on the Giblin coupe plus projected adjacent Forestry Tasmania harvest in 2008 (square symbols). (From McIntosh 2003.)

The overall conclusion from the water quantity calculations and modelling was that, provided forests adjacent to the Giblin block are not harvested before 2008, it is unlikely that clearfell and regeneration forestry operations on the Koonya uplands will have any negative effect on water quantity in streams, and on Koonya B spring yields in particular.

CONCLUSIONS

The detailed investigations have established no connection between recent forestry operations and turbid water at the Koonya B sampling site. The water monitoring evidence shows that since 1994 water at the Koonya B spring has been habitually turbid, and turbidity levels have neither increased nor decreased significantly since 1994 (Table 1). Other water quality measures also indicate no trends over time (Table 1). Tunnel gully erosion and (more recently) natural tree overturn in the Koonya B catchment is likely to have contributed to turbidity at the Koonya B sampling site (Figure 4). The detailed recent investigations substantiate Weldon's (1991) conclusions regarding water quality concerns which are repeated below:

- "It is considered that any component of spring water derived from a fractured-rock aquifer system will be unaffected in quality by forestry operations east of the Mt Koonya ridge line. The ridge is some 500 m distant from the nearest known spring and any suspended load entering the aquifer in the logging area should have settled out before reaching the spring."
- "[Restriction of forestry operations to the area east of the Mt Koonya divide] will preserve the quality of spring water derived from infiltration through the talus slope deposit (i.e. near-surface groundwater) on the west side of the divide."
- "The Commission's [Forestry Tasmania's] proposed forestry management guidelines for the Koonya block are well reasoned. It is a cautious approach which should minimise the effect on stream and spring quality as well as slope instability. In reality, the effect is expected to be negligible."

Provided forestry operations conform to the Forest Practices Code (Forest Practices Board 2000) and provided operations in the study area are restricted to the area east of the Mt Koonya – Kingston Pinnacle divide (the ridgeline referred to by Weldon (1991), and measures like matting and cording are routinely used (see McIntosh 1999), no deleterious effects of forestry operations on water quality are anticipated. The effects of forestry operations on water quantity are estimated to be an average increase in deep infiltration (and eventual streamflow) of about 23% for the first 29 years after harvesting begins and a slight decrease and then a slight increase of deep infiltration and streamflow (relative to 2003 flows) over the next 40 years. These slight increases and decreases are likely to be undetectable, given the natural variation of flow. Using different assumptions (i.e. assuming that the Koonya B spring is fed from a c. 60 ha catchment rather than from a large subsurface aquifer) no negative effect on water yield at the Koonya B spring is predicted, although as a precautionary measure it is recommended that any forest harvest adjacent to the Giblin block should not occur before the year 2008. The analysis of estimated flows substantiates Weldon's (1991) conclusion that "Forestry operations east of the ridge line [Mt Koonya to Kingstons Pinnacle] are assessed as having only a remote probability of affecting the spring water quality and quantity."

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