The portion of the area not taken up is fortunately absolutely worthless and no one wants it.

SWAMPS.

It is impossible to shew the swamps on a map as individually they are mostly small. They are covered with rank grass, and except in very dry seasons are treacherous to foot or horse traffic, having a thin caked surface over semi-liquid material.

The author was, unfortunately, only able to sink holes in one small swamp, and in that case there was about eighteen inches of peaty loam at the surface, and six feet of white sand below in one hole and in the other round quartz pebbles in the sand. Although these holes were sunk in February of this year—three months after any rainfall—there was about three feet of water in the holes; this gradually diminished till in two or three months one became dry and the other had only a foot of water in it.

It is probable that the large swamps, such as those at the head of the Loddon River are over twenty feet deep

The swamps are really the mainstay of the Sydney Water Supply. They are the only source of supply in the Summer months, acting as natural storage reservoirs, but whether we make full use of them or not is a question that deserves the careful consideration that is now being given to it by the authorities.

There is no doubt that the swamps lie in a rock basin, and almost invariably the water flowing off, runs over a rocky bar. Sometimes the swamps are in the form of a wide valley, and at others a large comparatively flat area. In either case the surface is not flat, but varies from a slope of about one in twenty, to one in a hundred. Although the slope is so great the water does not settle in the lowest portion but remains in the side of slopes (of a valley) suspended in the soil, the higher portions being generally considered the worst to get bogged in.

The swamp in which trial holes were sunk had ceased to give off water to the river for months, yet still stored a great quantity which was all lost as far as we are concerned by evaporation. If that be the case in the large swamps we certainly do not take full advantage of their storing capacity, since they cease to contribute while still saturated, or nearly so.

Any attempt at ruthless draining would be calamitous, but it might be possible to cut an outlet to a swamp through the rock bar of such a size that it would not drain it in six months.

Up to the present there has been such an abundant supply, and to spare, that there was no necessity to consider whether every drop was obtained from the swamps, but the present unprecedent drought has drawn our attention to such theoretical questions as this and the following question of timber, and they are now under the consideration of the authorities.

TIMBER.

One other natural feature that influences the flow off of rainfall is the timber.

Excepting for the swamp areas and part of the populated areas, the whole is densely timbered.

There are many patches of large Ironbark, Woollybutt, Blackbutt, Stringybark, Messmate, etc., but for the most part the timber is stunted while gum and blood wood, with occassional fine trees. The river banks—when not cliffs, are covered with dense scrub and whip stick, principally wattle, flooded gum, pine, coach wood, etc. Right on the highest portion of the mountain near Bulli Pass, there are fine turpentine, cedar, and other useful trees.

Now to what extent is timber on a catchment area beneficial?

The effects produced by trees are numerous and conflicting. The roots crack the ground rendering it more porous, but the water absorbed is not stored and allowed to get away later on: they also form ridges on the surface which prevent the water running off. When a tree dies, the roots rot and leave hollows near the surface.

Leaves, bark and other rubbish collecting at the foot of a tree, also form obstructions to the surface flow: leaves also catch much rain. But perhaps the principal effect timber has is the absorbtion of water necessary for its growth. The amount of absorbtion by vegetation cannot well be determined, but in the Annual Rainfall Report for New South Wales for 1882, Mr. H. C. Russell states that "experiments made in connection with European forests have shewn that a moderate sized tree will absorb from the ground sixteen gallons of water per day." Whether this be reliable or not, there is no doubt whatever, from observations of a practical rather than a scientific nature, that trees and the Eucalypti especially, absorb an enormous quantity of water.

Another great evil is that dead trees, fallen limbs, leaves, &c., intensify bush fires, and burn the ground to a considerable depth, whereas a grass fire would merely scorch the surface. During the past summer, bush fires raged over a great portion of the watershed, lasting for weeks, and this had the effect of intensifying the disastrous drought.

It is necessary to have trees, but when it becomes a question of making the best use of an area for a certain purpose, should they be allowed to grow anyhow? If the area were bare and trees had to be planted, they would be placed for a definite end; but because they happen to be there spaced by nature to serve other ends than merely as they affect the rivers, is it quite correct to assume that they are at the best for that one purpose only?

There are certain benefits to be derived from the presence of trees. By their shade they prevent evaporation, and by disturbing passing clouds increase the rainfall. The latter is a point that is still debatable, but we will admit it, as there is no doubt that moisture drops from leaves after a fog, frost, or dew.

Coming from theory to actual experience, there are numerous examples of permanent springs having started after an area has been cleared, and this is an observed fact on the catchment and almost anywhere.*

* Two papers which give measured flows after clearing were read before the Royal Society of New South Wales, by Mr. W. G. Abbott on—"Ringbarking and its Effects" (1880), and "Forest Destruction in New South Wales, and its effects on the flow of water, in water courses and on the rainfall."

All theory and experience points to the fact that while trees are necessary they are sometimes harmful, and it remains to be proved at what point of density of timber the advantage ceases. If trees, instead of being a few yards were a chain or more apart, they would grow larger, and have more luxuriant foliage, thus improving the chances of causing rain and also giving better shade. Then the trees on sunny slopes would need to be closer than on slopes away from the sun.

No rule can be fixed, every small portion must be dealt with separately; many experienced bushmen can state positively what will be the effect of clearing any particular portion, and careful observation would show the extent to which general thinning could be carried on with advantage. The timber at the edges of swamps being removed would probably increase the area of those swamps, which through the timber encroaching slowly but surely are becoming smaller.

Mining.

There is one other natural feature that may affect the watershed, namely, the presence of coal beds comparatively near the surface.

The beds opposite Bulli are over 1000 feet below the surface, but behind Mt. Kembla the depth is only about 300 feet. There are numerous Basalt dykes in these parts, which by destroying the continuity of the Strata are sufficient to permit water from the surface to find its way into a mine.

There is no surface mining on the area, the little that used to be done being stopped by the Sydney Water Supply authorities. There were a few prespectors for diamonds at Diggers Creek near Mittagong, and a start was made at a paint mine near Sherbrooke. A large area has been pegged out near Bulli Pass for iron, but the authorities have prohibited the working, and considering that it is on the Loddon River, one of the best feeders in the area, it is to be hoped it never will be sanctioned.

Rainfall, &c.

There is so little population that it is impossible to have sufficient stations for rain returns, to arrive at a proper mean for the catchment of any one of the rivers.

On the Cataract River there is only the gauge at the Cataract Tunnel Mouth,—on the Cataract Creek only one at Sherbrooke,—on the Cordeaux River only one near the head, while the Nepean River rainfall until lately was taken to be the same as at Robertson and Mittagong, both of which are outside the area (which assumption has proved very incorrect as frequently the rain at Robertson does not cross the ridge, and this year particularly the disparity has been very noticeable).*

The average Annual Rainfall up to 1900, at:—

Sherbrooke is	64·43	inches.
Cordeaux is	61·31	,,
Robertson is	70·91	,,
Cataract Tunnel is	34·77	,,

All but the last of these are near the heads of the various rivers, the last at the off-take.

* Gauges have recently been established at lower Mittagong, Robertson (No. 2), Bargo West and Wilton, all of which are on the watershed of the Nepean River.

The great difference between the rainfall at the source of any river and where tapped, makes it evident that the mean of the two is not the average of the river. The absence of population anywhere in the central portions, renders it impossible to divide the various basins into small areas, each with its own rain guage; this being the only way to obtain a true average for any river, or the whole area. The actual quantity of water that passes the tunnel mouth, and goes down the river has never been sufficiently investigated to enable a statement of the relation of rainfall to discharge to be prepared.

The loss must be comparatively small on account of the advantages derived from the natural features. The maximum distance the water has to travel in the river bed is only a little over thirty miles—the rivers are only a few miles apart radiating from an imaginary point near Wilton—and the deep creeks running into the rivers give every facility for the rain to reach the river bed in the minimum time. The fall from the sources to the off-take is 800 to 1,500 feet, and almost throughout their entire lengths the confines are solid rock, while either trees or cliffs mitigate the effects of the sun and wind.

With the exception of the swamps and part of the populated area, it is doubtful if there be more than a few feet of cover to the solid rock, and for a large part no cover at all. The slopes are so steep that the surface flow after rain has little time to sink in as it rushes down.

The rapidity with which the rivers rise and fall after a rain storm is the best proof that the natural features assist the water flowing off, and also that the loss must be small.

After a storm the rivers will rise rapidly reaching their highest immediately after the storm, and subside again rapidly.

The mean annual evaporation at Cataract Tunnel is 35·9 inches.

CONCLUSION.

Taken as a whole, the present watershed for the Sydney Water Supply is as nearly an ideal area as it is possible to expect.

The water is excellent in quality and the mean annual rainfall very high. The surface consists almost entirely of Hawkesbury sandstone in horizontal beds minimising loss due to percolation in Strata. There is barely any Wannamatta shale. There are large spongy swamps which form natural storage reservoirs. There is little population, and the greater portion is useless from a commercial stand point.

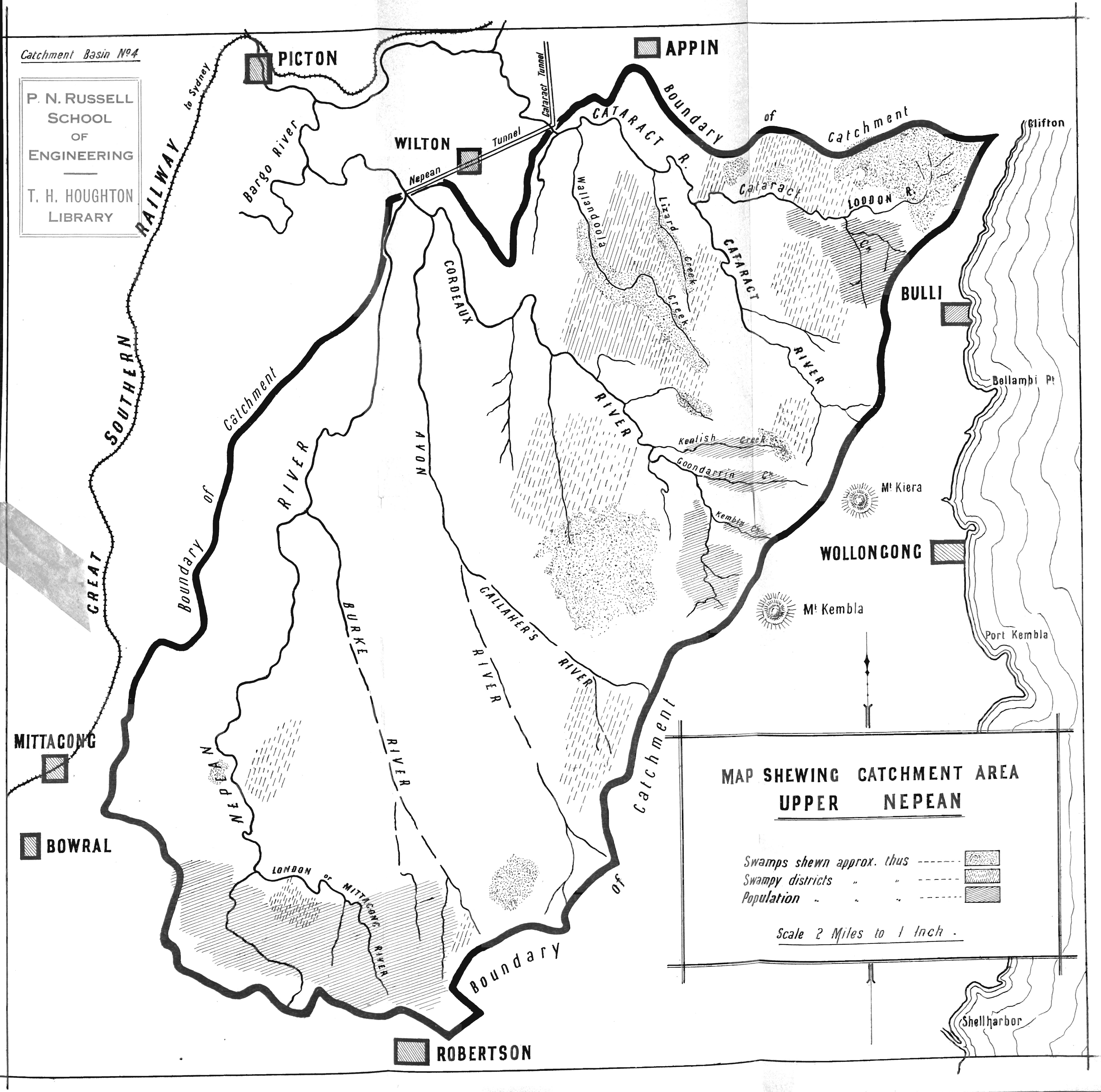
Although not bearing on the subject at all, a paper touching water supply just at present would be incomplete without some reference (as a record) of the present calamitous drought.

The rain returns are simple, accurate, and convey the best conception of the drought.

The thanks of the author are due to Mr. J. M. Smail, Engineer-in-Chief and other officers in the Water and Sewerage Board, for permission to use plans and statistics.

	SYDNEY.			SHERBROOKE.			CORDEAUX.			ROBERTSON.			CATARACT TUNNEL.		
	Inches.	Days Rain.	Most in 24 hrs.	Inches.	Days Rain.	Most in 24 hrs.	Inches.	Days Rain.	Most in 24 hrs.	Inches	Days Rian.	Most in 24 hrs.	Inches.	Days Rain.	Most in 24 hrs.
DECEMBER, 1901	0·52	7	0·30	0·72	5	0·31	0·36	6	0·10	0·32	3	0·27	0·54	3	0·32
JANUARY, 1902 ..	1·77	15	0·70	3 02	9	1·00	2·09	8	0·63	3·85	6	2·20	2·51	9	0·77
FEBRUARY, ,, ..	0·34	11	0·14	1·16	8	0·42	0·96	10	0·26	0·41	4	0·13	0·16	5	0·05
MARCH ,, ..	2·38	18	0·69	2·62	15	0·47	1·91	13	0·47	1,89	10	0·60	0·82	8	0·68
APRIL ,, ..	2·67	14	0·56	2 46	11	1·49	2·58	7	1·95	2·40	7	1·00	0 88	5	0·78
MAY ,, ..	1·21	14	0·51	2·06	9	0·76	1·56	8	0·64	1·30	4	0·50	0·24	7	0·09
JUNE ,, ..	0·63	10	0·35	0·56	8	0·23	0 72	6	0·26	0·79	5	0·42	0·57	11	0·30
JULY ,, ..	9·24	15	1·94	3·08	11	0·69	2·49	11	0·64	9 37	11	2·70	1·35	11	0·74
AUGUST ,, ..	6 32	20	1·26	4·48	16	0·85	3·12	12	0·47	2·78	8	0·90	1·20	15	0·25
SEPTEMBER ,, ..	2·10	14	0 55	2·34	14	0·59	1·59	8	0·61	1·37	7	0·50	1·34	9	0·55
Total 10 months ..	27·18			22·50			17·38			24·48			9·61		
Mean Annual ..	49.66			64·43			61·31			70·91			34·77		

The above Table gives the rainfall on the area, and for comparison at Sydney.


Catchment Basin No4
MAP SHEWING CATCHMENT AREA
UPPER NEPEAN
Swamps shewn approx. thus
Swampy districts
Population
Scale 2 Miles to 1 Inch.
PICTON
APPIN
WILTON
BULLI
WOLLONGONG
MITTAGONG
BOWRAL
ROBERTSON
to Sydney
GREAT SOUTHERN RAILWAY
Bargo River
Nepean Tunnel
Cataract Tunnel
CATARACT R.
Boundary of Catchment
Cataract
LODDON R.
Ck
Wallandoola
Lizard Creek
Creek
CATARACT RIVER
CORDEAUX RIVER
Kentish Creek
Goondarrin Ck
Kembla Ck
Mt Kiera
Mt Kembla
Clifton
Bellambi Pt
Port Kembla
Shellharbor
NEPEAN RIVER
AVON
BURKE RIVER
RIVER
CALLAHER'S RIVER
NEPEAN
LONDON or MITTAGONG RIVER