TRA 107-135

SUGGESTED IMPROVEMENTS TO WATER SUPPLY AND FILTER AT LAKE NO-WHERE-ELSE, KENTISH MUNICIPALITY, TASMANIA

by I. B. Jennings.

The filter beds of the Kentish Council's improved water scheme, Lake No-Where-Else, were examined with a view to identifying silty layers which have been built up in the fine sand bed, and to suggesting any general improvements to the existing plant. It was hoped that a cheaper method of cleaning the filter beds could be devised or some adjustment made which would result in longer filter runs between cleaning.

Owing to the necessity for a large filter bed area, and for periodic manual cleaning, the use of slow sand filtration has declined considerably in Australia. Most water purification nowa-

days is carried out by means of the rapid-gravity or pressure type filters, which can treat highly turbid and polluted waters effectively and economically. Use is usually made of prior chemical flocculation and settlement before filtration, and the filter beds need then be only a fraction of the size necessary for slow sand filtration. For example, in the Launceston plant a total filter area of about 400 square feet is sufficient to treat 2 million gallons per day, whilst the Kentish Council's slow sand filters require an area of 1,800 square feet to treat 100,000 gallons per day. Filter beds such as those used by the Launceston water works are cleaned at intervals of only a day or so by means of backwashing with air and water or by water alone, through specially designed and patented nozzles. Thus, the filters are kept free from sludge at all times.

Similar apparatus for backwashing filter beds of the size employed by the Kentish Council would be expensive both in initial outlay for installation, and in the water requirements of the washing process. It seems therefore, that the Kentish Council will have to continue cleaning the filter beds by scraping, when the flow rate becomes too low. It must be realised that if a slow sand filter is working efficiently, then by its very nature, sludge formation is to be expected. The most promising field for improvement lies in trying to cut down the rate of sedimentation into the dam and in modifying the water inlet.

However, it would be worth while for the Council to have the existing plant examined by a representative of one of the companies which specialise in this type of installation, to get an opinion as to whether chemical flocculation and/or a filter washing system could be economically incorporated into the present design. It may even be found economical to install a rapid-gravity pipe filtration plant in place of the present system and thus avoid the expense incurred in inhibiting sedimentation and pollution of the reservoir. Before proceeding with any such proposal it would first be necessary for the Council to determine the long-term water requirements of the municipality and, perhaps more important, the safe maximum draw-off from the present dam. Particulars of two firms specialising in such equipment are appended.

During the examination of the filter basins the points set out below were noted. The examination was confined to the fine sand layer and to the top portion of the medium sand of No. 1 filter. No. 2 filter was examined superficially but since at the time of examination the fine sand was saturated from one foot below the surface, no detailed sampling of this filter was possible. It is considered that the remarks concerning the No. 1 filter apply also to the No. 2 filter.

1. The material comprising the fine sand bed apparently does not conform to specification. The specification states " the material shall be pure quartz sand free from clay, loam or any form of vegetable matter and shall conform to the following close limits of grading:

> (*a*) Fine Sand:—100% passing No. 14 sieve and 100% retained on No. 25 sieve ".

The specification does not state which type of sieve should be employed. If the sieves referred to are British Standard sieves, as appears likely, then between 70% and 80% of the material in the fine sand layer is oversize. The attached grain size analyses demonstrate this.

2. Council employees engaged on cleaning the filter beds reported layers of fine sediments within the fine sand layer. Several such layers were noted by the writer at various levels in both filters. In a part of No. 1 filter, a layer of fine silt, clay and vegetable matter, up to two inches thick, was observed at the interface between the fine and medium sand. These layers, being largely impermeable, are undesirable for the following reasons:—

(*a*) They restrict the available filter bed area considerably and therefore contribute directly to the slow filtration rate.

(*b*) They may cause high rates of flow through the remaining portion of the filter bed. This could result in less effective filtration which would be encouraged by the fact that the fine sand is so much oversize.

The material which forms these silty layers is a banded, greyish-white, clay-silt mixture composed largely of fine quartz particles; it contains fine rootiets. The writer is convinced that the formation of these layers is due to impurities in the original fine sand as delivered. This is supported by the following:—

(*a*) The layers are composed of material quite different in composition from that which is now being deposited as sludge on the filter bed. The water from the dam deposits a sludge consisting mainly of brown, clay-size particies, with vegetable matter mainly in the form of leaves.

(*b*) The layers have built up within, and at the base of, the fine sand bed and not on the surface of it.

(*c*) Grain size analysis and loss on ignition (the latter a rough measure of the percentage of vegetable matter present) show that the silty layers differ considerably from the sludge accumulating on top of the fine sand.

The indications therefore are, that in this respect also, the fine sand did not originally conform to specification.

Some improvement in the infiltration rate was effected by breaking up one or more of these layers with forks, near the surface of No. 2 filter. Such a course will certainly effect an immediate increase in the filtration rate, but eventually the fine material will settle out again as a layer further down in the filter beds. It is evident that the fine sand should be removed and replaced with more suitable material as soon as possible.

3. The specification for the medium sand called for material of the grading between — No. 8 and + No. 14 sieve. Again, assuming that these sizes refer to the British Standard sieves it appears that this material does not conform to specification. The grain size analysis of sample No. 839-10 is from a sample taken of the silt layer which occurs at the junction of the fine and medium sands in No. 1 filter. It includes material from both layers as well as from the siit deposit between them. The analysis shows that 28% of this material is coarser than No. 8 sieve.

The most astonishing feature is that such a deposit could accumulate above the medium sand at all. Correctly, in a coarse deposit of this grading, all such fine material should pass freely through it. The fault seems to lie in the particle shape of the material employed as medium sand. For this bed, crushed quartz

and quartzite have been used, the resulting particles having a flakey shape. Thus, although in two dimensions some of the medium sand exceeds the specified size, the shape of the particles is such that they tend to lie flat and restrict the effective permeability of the bed. Since the specifications did not contain any restrictions as to particle shape, the material does not in this respect, fail to comply with the specifications. However, it is clear from the very fact that these relatively impervious layers have been able to build up on top of the medium sand, that it would be desirable to replace it with material having a better shape.

4. The water inlets to the filter beds could be improved. At present, after the filters have been cleaned, the water, when re-admitted, falls several feet without restriction onto the top of the fine sand bed. During the early stage of filling, the fine sand is scoured out to a depth of 12-18 inches by the incoming water. This could be serious if the overall depth of the filter bed has been greatly reduced by cleaning, as is at present the case. If the filter bed was reduced sufficiently in thickness to allow scouring to take place right to the base of the fine sand layer, then possibly the majority of the water entering the filters would simply pass through the small scoured areas below the inlet pipes, resulting in higher velocities, and inhibiting effective filtration. A non-scour inlet, or perhaps a reverse filter over the area subject to scouring is certainly desirable.

5. During the time that the filters have been in operation about a third of the fine sand bed has been removed during cleaning operations. (The fine sand bed of No. 1 Filter is now only two feet thick). At present no facilities exist for washing the sand which has been removed, or for storing any clean sand on the site. A wooden or concrete apron for storing new or cleaned sand is necessary. As to whether it is cheaper to wash the dirty sand removed from the filters and to re-use it, or to replace it with new clean sand is a matter of economics depending upon the cost of the new sand (if perfectly clean material can be obtained) and upon the amount of water required for washing.

6. During the examination the writer profited by discussions with the chemists in charge of the Launceston and Beaconsfield water filtration plants. It seemed likely to the author, and informed opinion supports the view, that filtration would be improved by employing a somewhat finer medium for the fine sand layer. Sand having a general grading between — 36 BS and + 60 BS is recommended. Although extremely close grading of the sand layers is necessary in rapid gravity filters, it is not regarded as absolutely essential for slow sand filters. A sand which conforms strictly to a grading between — 25 BS and + 85 BS, with the majority of particles between — 36 BS and + 60 BS would be suitable. In any case, it is clear that the existing fine sand will have to be replaced as soon as possible and I suggest that material of the above grading be used in its place. This would possibly be cheaper than the sand in use at present. All material intended for the fine layer *must be examined* to ensure that it complies strictly with the specifications regarding impurities such as clay, silt, loam and vegetable matter; it should be clean, rounded quartz sand, free from flaky particles. The grain size of the underlying medium sand, which also requires replacement, will have to be decreased in proportion. *It may well be found that even new sand will have to be washed before it is suitable for use.*

It may be held that the use of a finer sand, as suggested above, will only slow up the filtration rate even more. However, the author considers that the following factors are, to a large extent, responsible for the present slow filtration rate and comparatively short filter runs:—

(*a*) The presence of the thin impermeable, silty layers. These must restrict the effective flow through the filters and the situation can be remedied only by completely replacing the fine sand with clean material.

(*b*) Relatively heavy sedimentation occurring in the storage lake, owing to the proximity of the road and to the cultivation of land surrounding the lake. Early consideration should be given to halting cultivation within the catchment area and to ensuring that all this land is immediately sown down into permanent pastures and kept well grassed at all times. At present, sudden rain storms onto the ploughed land surrounding the reservoir produce flows of highly turbid water, which carry large quantities of clay in suspension into the storage. This undoubtedly clogs up the filters rapidly. It is for the Council to decide whether the land in question can, or should be acquired; or whether suitable arrangements can be made with the present occupants.

During the dry weather, dust stirred up by traffic along the Barrington-West Kentish road probably makes a significant contribution to the material in suspension in the lake water. The presence of the lake seems to create a draught from the road down over the storage; also, the prevailing winds are in that direction. Admittedly, the amount of dust created by a single vehicle is small, but during the summer the road is subject to fairly heavy traffic. Also, when the dust menace is at its height, the lake level is at its lowest, so dilution is reduced. The majority of the material which drifts from the road to the lake is so fine that it probably goes into suspension and therefore into the filters. The remedy for this is to seal the road in the vicinity of the reservoir; if conditions become serious enough to warrant it before the sealing can be effected, then it may be desirable to water the road during the periods when the reservoir level is lowest.

It should be noted in this connection that the total volume of clay size material necessary to choke the filter is very small. The grain size analysis of sample 838-9, taken from the top of the silted filters, shows that less than 2% of clay size (—200 BS) material is present. This means that less than a quarter cubic yard of clay is sufficient to slow down the fiiter enough for cleaning to become necessary.

7. Some consideration may be given to improving a floating take-off in the dam. This would ensure that the clearest water available would be drawn off, and would cut down the discharge of sludge, &c., onto the sand bed. Such an arrangement may readily be made with a suitable pipe fitted with a flexible hose connection, the inlet end being attached to a floating drum, moored to prevent drift.

8. The relative coarseness of the filter beds at present suggests that if the filters were clean and free from silt layers, then filtration for the first few weeks would not be very effective. Analyses of water taken shortly after cleaning the filters appear to support this view. I suggest that if it becomes necessary to clean the filter beds at the height of a dry summer, when the lake level is very low, there is some danger of polluted water passing through the filters immediately after the cleaning. The coarse sand at present being employed as a filter medium, the reduction of thickness of the filter beds due to repeated cleaning without replacement, the danger of scouring around the inlet pipes and the sources of pollution which exist in the vicinity of the dam all combine to make this a real factor to be considered during the coming summer. Chlorination may be desirable for the first few weeks after cleaning the filters, and a prior investigation as to probable dosages and the point of addition, &c., is suggested before the coming summer, in case the necessity should arise. Chlorination may also help to control algal growth and thus give longer filter runs.

POLLUTION

The water in Lake No-Where-Else is at present subject to pollution from a number of possible sources. Within a few hundred yards of the dam, and right down to the water level, about 100 head of stock are being grazed. A dairy, a piggery, and pouitry runs are situated within a short distance of the dam; the effluent from some of these flows directly into the creeks which feed the dam. The encouragement of fishing in the dam presents a further source of possible pollution. Beer bottles have been recovered from the filter basins and a live wallaby has been found swimming in the filters. Under certain conditions the wallaby could have remained undetected in the filter for perhaps a week. Possible pollution of water in the filters, and particularly in the clear water basin, is obviously a serious matter and consideration should be given to fencing these areas off from human and animal visitations.

The restriction of grazing and dairying activities in this immediate area is a more difficult matter as it could perhaps inflict hardships upon individuals, or else involve the Council in heavy financial obligations for land resumption. Perhaps some steps could be taken to assist in moving the dairy and pigsties out of the catchment area or to provide settlement traps which could be periodically disinfected. In view of the present condition of the filter beds, a study of the general problem of pollution in this area, by appropriate authorities, seems to be warranted.

Over the years, bacteriological tests of water from this dam have shown that serious contamination at present is unlikely. However, the noticeable additions to the possible sources of contamination, combined with the steady rise in water consumption, is increasing the risk year by year. It is therefore wise policy to take steps now, to assure that serious contamination does not occur. If the control of pollution is delayed until the danger becomes imminent, then the Council may well be involved in proportionately heavier expense to correct the situation eventually.

SUMMARY AND RECOMMENDATIONS

1. Slow sand filters must be expected to sludge up periodically. It seems that the only economic way of cleaning these filters will be by removal of the top layer of sand.
2. The fine sand at present used in the filter beds apparently does not conform to specifications, and should be replaced.
3. A fine sand of the grading suggested would improve filtration.
4. The question of washing sand removed from the filters during cleaning, or replacing it with new sand, is one of the economics which have yet to be decided.
5. Concrete or timber aprons, or storage areas, should be provided near the filter beds for clean, and for used sand.
6. The material used for the medium sand layer apparently does not conform to specification as regards grading, it has a poor particle shape. It should be replaced by water-worn material of the correct size to support the new fine sand layer which has been suggested.
7. A floating intake along the lines suggested is desirable.
8. Steps should be taken to cut down the sedimentation into the dam by encouraging, or enforcing, property owners nearby to sow down the land surrounding the dam and to keep it well grassed at all times.
9. Improvements to the filter inlet pipes should be made, or else a reverse filter provided under the inlets, to prevent scouring during filling.
10. Early consideration should be given to reducing the dust nuisance along the Barrington-No-Where-Else road.
11. Grazing in the immediate vicinity of the dam should be stopped or restricted, particularly in dry weather.
12. Enquiries should be made with representatives of the filter companies as to the cost of mechanical cleaning of the filters and possible improvements such as flocculation, &c.

Since it is unlikely that any alterations to the present filter beds can be made before the coming summer, it is suggested that some care be taken during this summer if the level of the lake becomes very low. Under such conditions, because of the coarse nature of the filter beds, their reduced thickness, and the possibility of scouring around the inlets, there seems to be a distinct risk that if cleaning is necessary, polluted water could pass through the filters immediately after they are put back into operation.

It should be noted, however, that even if the filters were to become markedly inefficient, the settlement effected by the clear water basin and the reservoir will help materially in water clarification. Indeed, these units at all times make an important contribution towards water clarification.

If filter cleaning is necessary under very dry conditions this summer, the writer considers that the following steps are desirable:—

(1) Bacteriological tests should first be made of the water entering the dam and of the stored water in the dam.

(2) Every effort should be made to keep the reservoir as full as possible when the filters are put back into operation so as to gain the full advantage of settlement.

(3) A prior investigation as to dosages and addition points for chlorination should be made so that chlorination can proceed without delay if indicated by (1).

(4) A careful study should be made of all possible sources of pollution and the necessary steps taken to reduce or eliminate risk of contamination of the water supply.

APPENDIX

FILTRATION COMPANIES

CANDY MONIER, PTY. LTD., Mavis St., Revesby, N.S.W.

INFILCO COY. c/o A. G. Webster & Co., Launceston, Tas.

From conversations I have had with interested parties, I understand that whilst the equipment supplied by the Candy people is very good, it is much more expensive than the Infilco equipment. I believe that tenders for the new Beaconsfield water purification plant indicate that the Infilco equipment was significantly cheaper. It is regarded as being equally efficient.

GRAIN SIZE ANALYSES OF SAND SAMPLES.

(DEPARTMENT OF MINES LABORATORY, LAUNCESTON)

Sizing B.S.	*Reg. No.* 838-9	*Reg. No.* 839-10
+ 5 mesh	5·0%	16·6%
+ 8 mesh	12·6%	12·7%
+ 12 mesh	39·3%	9·9%
+ 14 mesh	16·8%	4·2%
+ 18 mesh	16·4%	5·4%
+ 25 mesh	3·2%	1·7%
+ 36 mesh	1·1%	1·4%
+ 60 mesh	1·1%	2·8%
+ 85 mesh	0·9%	5·6%
+100 mesh	0·3%	3·1%
+150 mesh	0·9%	10·1%
+200 mesh	0·6%	5·4%
—200 mesh	1·8%	21·1%

Reg. No.		Sizing B.S. Per cent +14	+25	−25
830	1	73·5	19·5	7·0
831	2	76·0	16·5	7·5
832	3	71·0	16·3	12·7
833	4	80·0	15·0	4·7
834	5	74·5	20·0	5·5
835	6	76·5	15·5	8·0
836	7	79·5	12·5	8·0
837	8	80·0	16·0	4·0

		Loss on Ignition Per cent
838	9	0·35
939	10	2·7

SAMPLES FROM NO. 1 FILTER

No.	Depth.
830-1	0″- 3″
831-2	3″-1′ 3″
832-3	1′ 3″-2′ 3″
833-4	0′ -1′
834-5	1′ -2′ 3″
835-6	0″- 6″
836-7	6″-1′
837-8	1′ 6″-2′ 3″
838-9	0″- 4″

(Bulk sample of sludge layer)

839-10 silt layer between Fine and Medium sand layers.