8.0 Appendix

8.1 Water Tank Improvements

8.1.1 Simple Measures to Improve Tank Water Quality, John Ashworth

WATER & WASTEWATER

SIMPLE MEASURES TO IMPROVE TANK WATER QUALITY

by John Ashworth

Dr Stan Abbott's' article in the May-04 issue of Water & Wastes in NZ titled, "Microbiological health risks of roof collected rain water" does emphasise the dangers in drinking roof collected rainwater. The internationally used pathogen indicator organism – Escherichia coli, zero per 100 millilitres – is accepted as a pragmatic means of deciding if drinking water is safe to drink. It is interesting to note that often a high level of pathogens needs to be ingested by a healthy person to contract the particular disease. The median – not minimum - infective doses are:

- Vibrio cholerae and Salmonella typhi, one million bacteria
- Giardia lamblia, 100 cysts1
- Ascaris, 100 helminths1

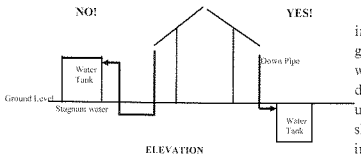
Following the WHO Drinking Water Guideline risk philosophy, it is necessary to take into account the amount of water drunk to decide what level of contamination is a significant risk. Out of a design volume of 180-litres per capita day, probably, in summer, less than one litre a day is drunk as cold water. The body's daily requirement will come from food, drinking boiled water (tea and coffee), milk and bottled drinks, such as beer. One litre (ten-100 millilitres units) of water drunk cold allow high levels of pathogens before an infection is acquired. For cholera, this could theoretically be 100,000 bacilli per 100mL of cold water drunk by a healthy person during a day.

Choosing zero E.coli per 100ml of water does have a safety factor that is particularly appropriate for supplying a large dense urban population with drinking water, but less important when it is an isolated farm house with three people living in it. The exception is immune deficient communities and these already know the serious risk of even shaking hands with a friend who has flu and the importance of drinking safe water – boiled to ensure the chlorine resistant Cryptosporidium oocysts are killed.

Some 4% of the New Zealand population is served by roof water collection systems. Often little engineering is involved in the collection system, other than redirecting the spouting into a single 20 cubic metre water tank. Such basic design does lead to cases of gastroenteritis, but not an epidemic.

Behaviour change – but probably supported by council byelaws - is required to encourage a few simple devises to be included in the rainwater collection system to significantly improve the water quality:

1) Remove the Down Pipe "U" Column.



ELEVATION

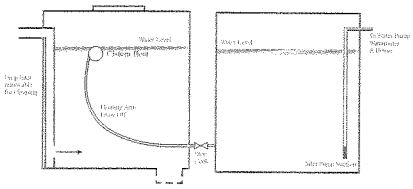
To save money in under grounding the water tank, the down pipe is laid underground as shown on the left in the above sketch. Water remains in the "U" column during dry periods. Particularly in summer with higher temperatures and longer periods between rains, organic sediment in the column becomes anaerobic and hydrogen sulphide is given off. This is then flushed into the water tank by the next rain and contaminates the whole supply. If the same sediment is flushed straight into the water tank (see right side of sketch) the 1,000 times greater surface area of the tank allows sufficient oxygen transfer to occur naturally, preventing the water becoming anaerobic as it would in a "U" column.

2) The Leaf Slide

The leaf slide, in principle, is a very small sewage treatment works run down screen. It removes leaves and rubbish washed off the roof and any dead birds stuck in the down pipe that the author found went through his first flush diverter.

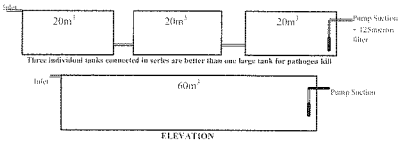
Some 4% of the New Zealand population is served by roof water collection systems.

2) Drop Inlet Pipe and Floating Arm Draw Off



Typically, the down pipe discharges at the top of the tank and, when there is heavy rainfall and a half empty tank, the force of the incoming water will re-suspend bottom sediment. Cryptosporidium oocysts will settle to the bottom of the tank if provided quiescence conditions that the drop inlet pipe supports. The floating arm draw off capitalises on the oocyst settlement and draws off water at the top of the tank that is likely to be free of protozoa. Water is drawn from below the surface to reduce contamination by pollen or floating debris.

3) Storage Tanks in Series



ELEVATION

First order kinetics shows that there will be a considerable increase in pathogen reduction if two or more tanks are used for water storage than one single tank. For example a faecal coliform contamination of 5,000 E.coli per 100ml is reduced to some 90 E.coli per 100ml after 100 days storage in a single 60 cubic metre tank. When two 30 cubic metre tanks operate in series, the result is some 6 E.coli per 100ml.

4) Kitchen Sink Micro Filter

For the small amount of water that is to be drunk cold, one-micron filtration provides additional protection against Cryptosporidium. It may assist in bacteria (0.5 to 6microns) and virus (0.02 to 0.3micron) removal. Domestic micro filters offer an activated carbon element that will reduce taint and odour.

These simple measures have shown WHO Drinking Water Guideline can be met without the need for disinfection. Compliance will fail if the household water demand is greater than the system capacity. When the storage tanks are close to empty, sediment containing parasites is likely to be re-suspended and drawn into the house supply.

Both councils and the two leading New Zealand plumbing schools have been approached to adopt these simple criteria as standard practice. So far there has been interest but no action to adopt. Could somebody please help before punitive legislation is passed requiring expensive systems for low risk rural community drinking water supplies?

Author: John Ashworth

References

Health Aspects of Excreta and Sullage Management – A State-of-the-art Review; Appropriate Technology for Water Supply and Sanitation: Feachem et all; World Bank 1980

8.2 Survey Results

8.2.1 Schools & Camp Facilities

8.2.1.1 Sample One

Source = Roof water
Cleaned roof and gutters = Annually
First flush system in place = No
Heating = Electric heating
Enough good quality water all year round = No
Treatment = water filter
How often is treatment system maintained = annually
Water tank underground = partially
Pipe work underground = No
Tank size = don't know – possibly 10,000L
How often clean tank/s = When necessary
Taste and odour problems = Yes – "tastes horrible, leaves come through."
Wants council water supply scheme = Yes – and willing to pay.

8.2.1.2 Sample Two

Source = Bore water
How long has bore being in use = 5+ years
Bore fenced of from stock = No
Area surrounding water take = Farmland
Enough good quality water all year round = Yes
Treatment = None
Water tank underground = No
Pipe work underground = Yes
Tank size = don't know
How often clean tank/s = When necessary
Taste and odour problems = No
Wants council water supply scheme = No

8.2.1.3 Sample Three

Source = surface water
Area surrounding water take = Farmland
Enough good quality water all year round = Yes
Treatment = Water filter and UV/Ozone
How often is treatment system maintained = regularly
Water tank underground = Yes
Pipe work underground = Yes
Tank size = don't know – "use 2 tanks; old school swimming pool and tank"
How often clean tank/s = don't know
Taste and odour problems = No
Wants council water supply scheme = No and don't know about paying rates.

8.2.2 Hospitality Industry

8.2.2.1 Sample One

Source = Surface and Roof water
Cleaned roof and gutters = More than annually
First flush system in place = No
Heating = Wood burner for the house and gas for the business premises

Area surrounding water take = Bush land
Enough good quality water all year round = Yes
Treatment = Water filter and UV/Ozone
How often is treatment system maintained = More often than annually
Water tank underground = No

Pipe work underground = No
Tank size = Don't know
How often clean tank/s = don't know
Taste and odour problems = No
Willing to let council test drinking water quality = Yes
Wants council water supply scheme = Don't know – "depends on price

8.2.3 Sports Facilities, Halls & Churches

8.2.3.1 Sample One

Source = Roof water
Cleaned roof and gutters = Annually
First flush system in place = No
Heating = Other
Enough good quality water all year round = Not always
Treatment = don't know
How often is treatment system maintained = don't know
Water tank underground = No
Pipe work underground = No
Tank size = 4001-5000L
How often clean tank/s = When necessary
Taste and odour problems = No
Willing to let council test drinking water quality = Yes
Wants council water supply scheme = Yes – and willing to pay rates.

8.2.3.2 Sample Two

Source = Ground water
How long has bore being in use = don't know
Bore fenced of from stock = Yes
Area surrounding water take = Farmland
Enough good quality water all year round = Yes
Treatment = don't know
How often is treatment system maintained = don't know
Water Tank = No
Taste and odour problems = No
Willing to let council test drinking water quality = Yes
Wants council water supply scheme = No

8.2.3.3 Sample Three

Source = Ground water
How long has bore being in use = don't know
Bore fenced of from stock = Yes
Area surrounding water take = Farmland
Enough good quality water all year round = Yes
Treatment = don't know
How often is treatment system maintained = when necessary
Water tank underground = No
Pipe work underground = No
Tank size = 10000+L
How often clean tank/s = when necessary

Taste and odour problems = No
Willing to let council test drinking water quality = Yes
Wants council water supply scheme = Yes – but not willing to pay

8.2.3.4 Sample Four

Source = Roof water
Cleaned roof and gutters = Annually
First flush system in place = No

Heating = none
Enough good quality water all year round = Not always
Treatment = none
Water tank underground = No
Pipe work underground = No
Tank size = 1001-2000
How often clean tank/s = When necessary
Willing to let council test drinking water quality = No
Taste and odour problems = No
Wants council water supply scheme = No

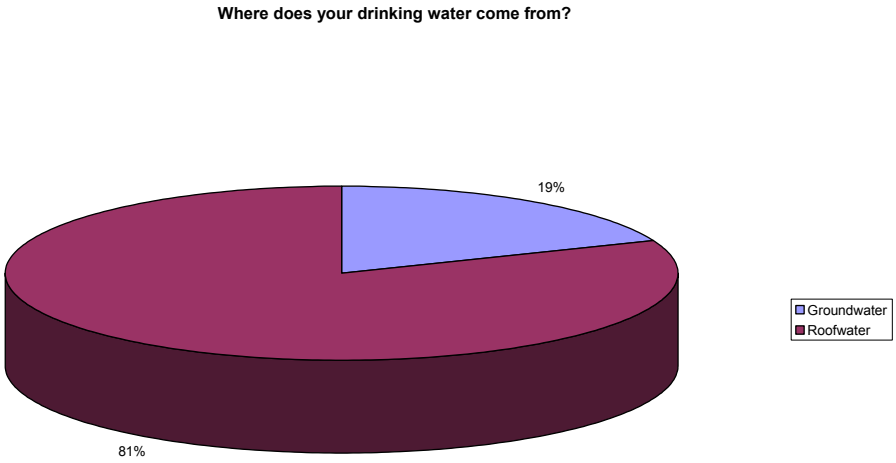
8.2.3.5 Sample Five

Source = Ground water
How long has bore being in use = don't know
Bore fenced of from stock = Yes
Area surrounding water take = Farmland
Enough good quality water all year round = Yes
Treatment = none
Water tank underground = No
Pipe work underground = No
Tank size = don't know
How often clean tank/s = never
Taste and odour problems = No
Willing to let council test drinking water quality = don't know
Wants council water supply scheme = don't know

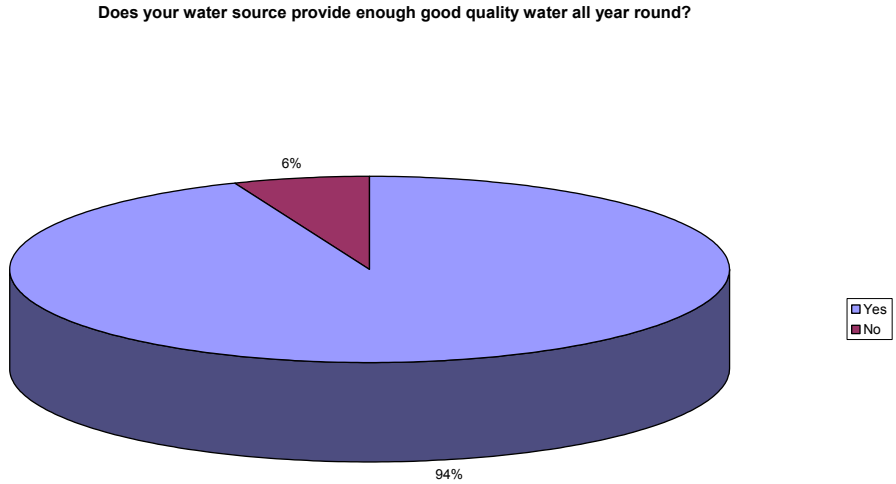
8.2.4 Plains Non-Serviced

8.2.4.1 Plains Western Ranges Non-Serviced, Sanitary Services Water Assessment Survey Results

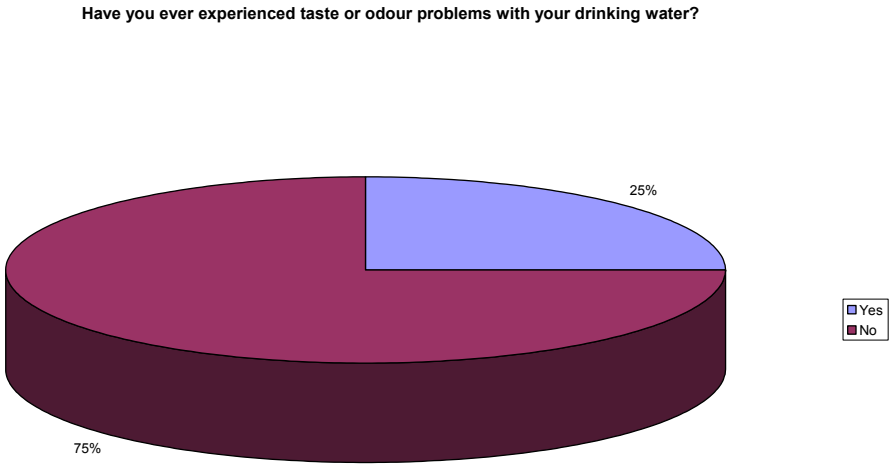
From the population of 54 properties a sample set of 38 was randomly selected to allow for 90% confidence with a 50% response rate. 19 responded from the Plains Hill area.



The majority of properties in the Plains Hill area sourced their dinking water from rainwater runoff from their roofs, 3 properties were on groundwater supplies, with one stating they were switching to roof water.

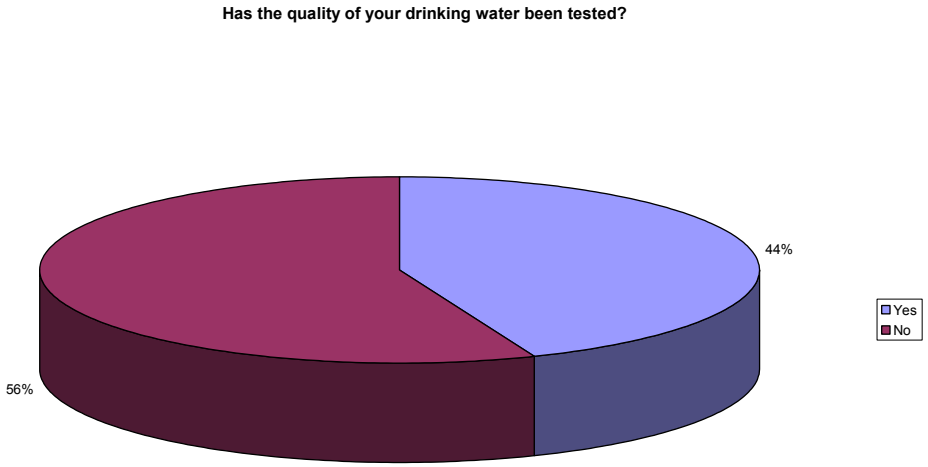


Only one respondent stated that their water source was not adequately meeting their needs all year round. The remaining 15 respondents were all very happy with their water supply.

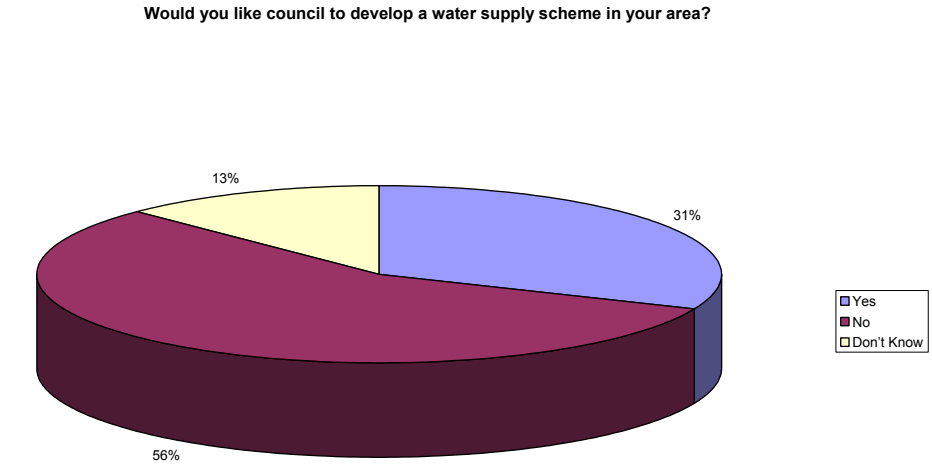


The majority of those surveyed from the Plains Hill area had never experienced taste or odour problems with their drinking water. Only 4 respondents said they had experienced taste or odour problems, and of these 3 had remedied the problem by either cleaning their existing filter or installing a new one, the other respondent attributed his taste/odour problems to stemming from the rotting peaches on his roof (his drinking water was sourced from the roof).

The favoured method of treating drinking water was the use of a water filter, 2 property owners had also installed UV treatment systems as an added precaution. The remaining 4 believed they didn't need any form of treatment as their water source was satisfactory.



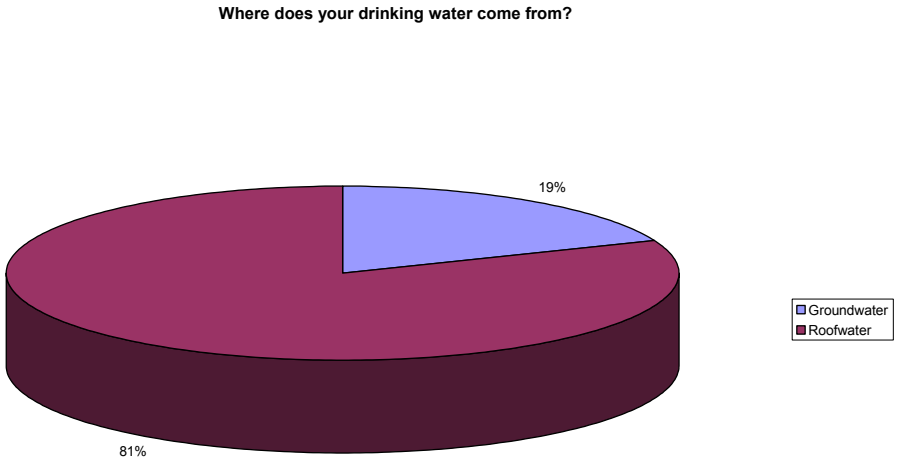
Approximately half of those properties surveyed had had their drinking water tested, and of those 7 properties that had tested their water 1 reported that the dairy company tests their water so as to maintain stock standards of health as well.



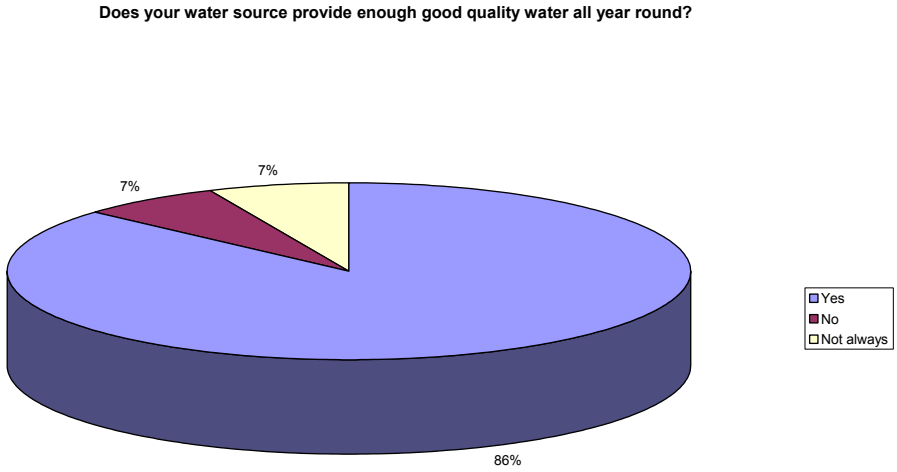
Of those surveyed in the Plains Hill area a significant number of property owners said they would like to see a water supply scheme developed in their area, and of these 5, 2 were prepared to pay for that service.

8.2.4.2 Plains Lowland Non-Serviced, Sanitary Services Water Assessment Survey Results

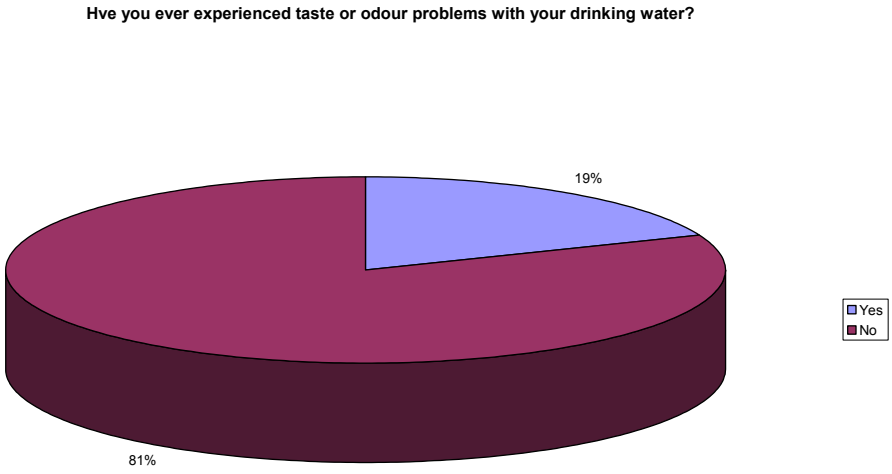
From the population of 72 properties a sample set of 43 was gained from calculating a random sample with 90% confidence allowing for a 50% response rate, 18 responded from the Plains Flat area.



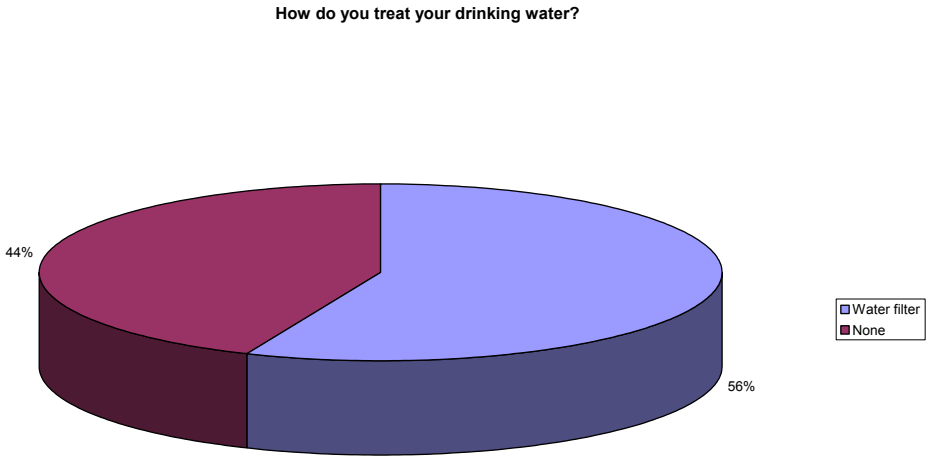
Of these 18 respondents with property on the Plains 81% sourced their water from rain collected of their roofs. As seen above.



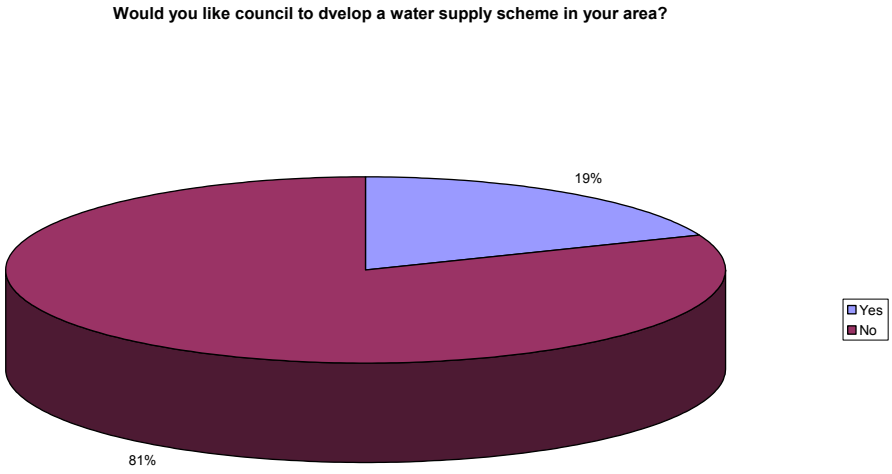
The majority of those surveyed said their water source provided enough good quality water all year round, as seen above.



Again a clear majority also stated that they had never experienced taste or odour problems with their drinking water, as seen above.



44% of respondents had no water treatment system in place. See above.



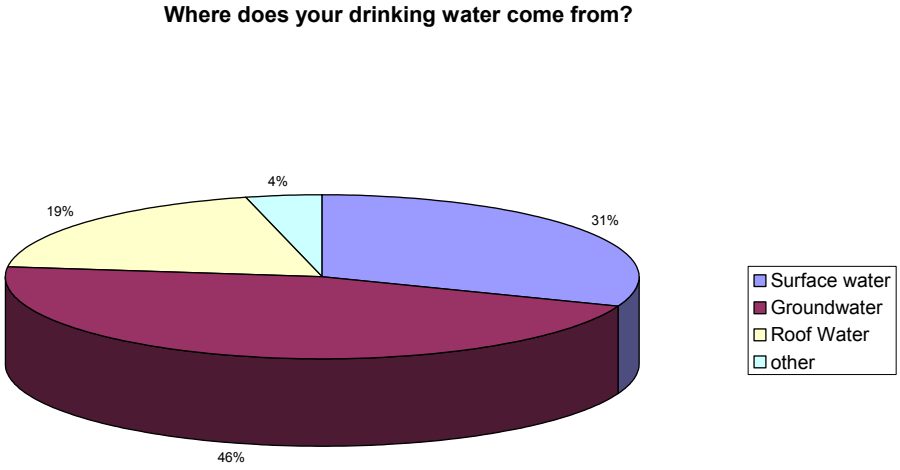
As depicted above a clear majority of residents in the Plans Flat area did not want a council water supply scheme in their area, most stated price as the major contributor to this opinion. But of those who said they did want a council water supply scheme in their area, all were prepared to pay for this service.

8.2.5 Rural Non-Serviced

8.2.5.1 Rural Non-Serviced, Sanitary Services Water Assessment Survey Results

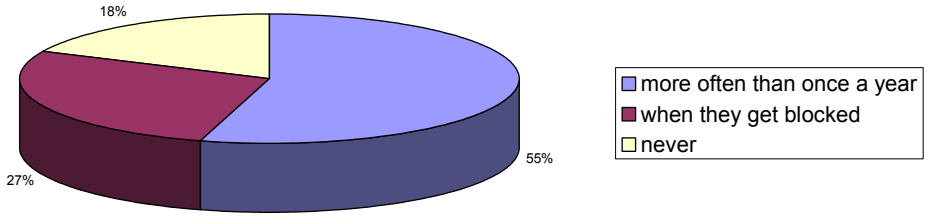
From a total of 312 properties connected to council water supply, we took a random sample of 48. This gave us a 90% degree of confidence with an expected response rate of 50%. 28 respondents from this sample met these specifications to give a reliable result set.

Of these respondents, 46% took their drinking water from the ground (springs or bores) while 31% took their drinking water from surface sources (streams, creeks and rivers) and 19% used roof water. Other sources for drinking water included bringing drinking water to the property in containers. This was in the case of holiday homes or businesses.



Of those who use rain water run off from the roof for their drinking water, 82% clean their gutters; 27% when the gutters get blocked, 55% more often than once a year. The remaining 18% never clean their roof and gutters. 27% of roof-water users have a first flush system installed.

How often do you clean your roofs and gutters?(roofwater users)

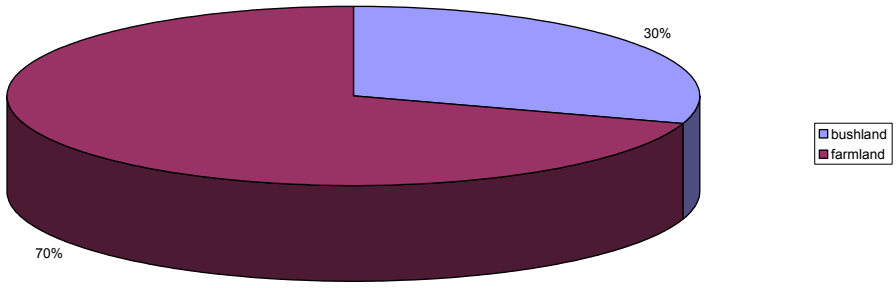


7 roof-water users used wood-burners, while 2 used other types of heating systems (these included gas and booster system heating).

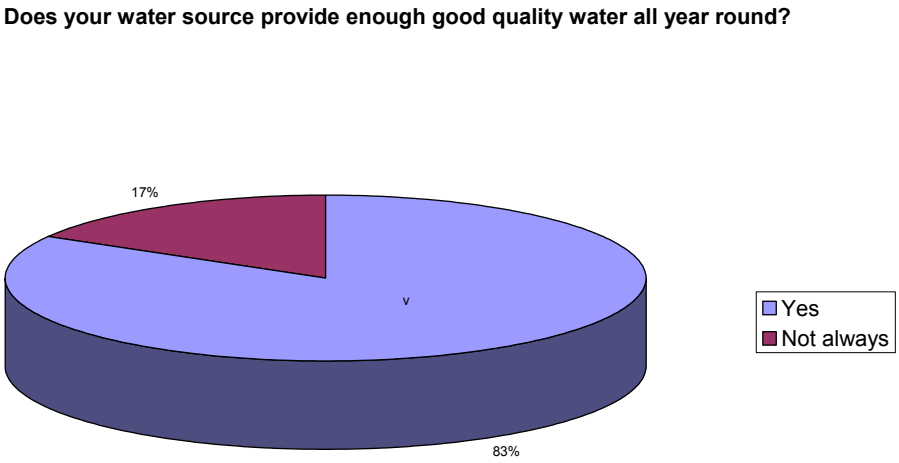
77% of those who used water taken from a spring or bore reported the age of the spring or bore to be mostly older than 5 years. All but one reported their spring/bore to be fenced off from stock.

Water supply has been mostly defined as being taken from farm land:

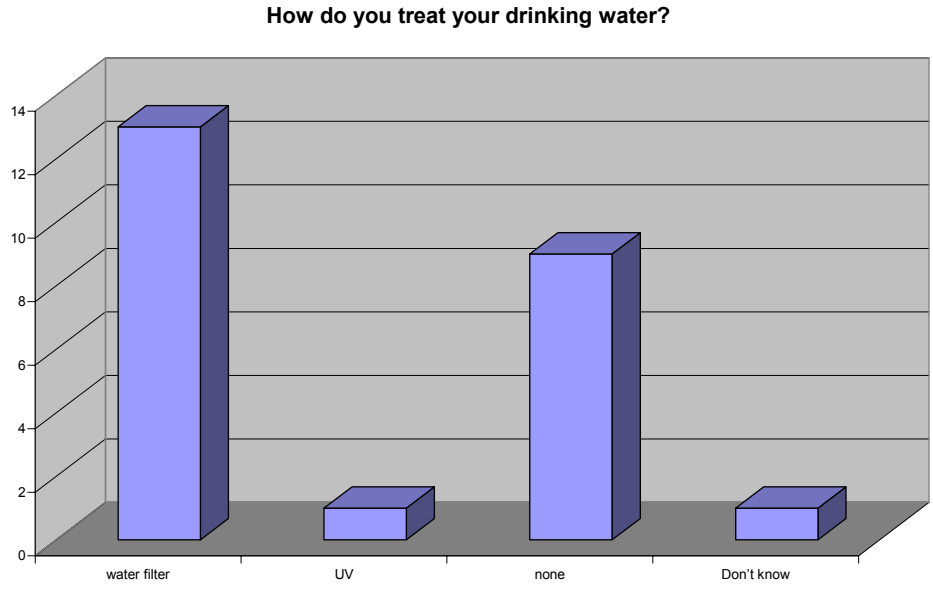
Where would you say your water supply is collected from?



83% were of the option that their water supply provided sufficient good quality water all year round. Reasons water supply was not seen as sufficient or not of good enough quality included: that the water ran out in summer, and that there were mineral deposits present, although these owners had installed a filter system to deal with this problem.

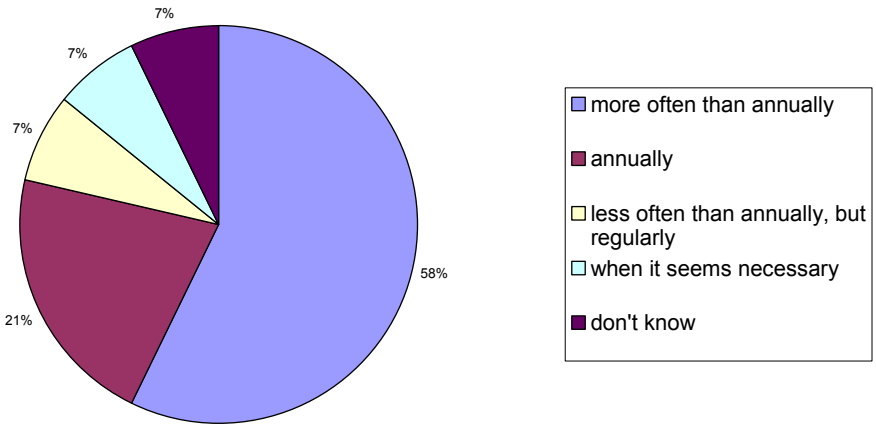


12 respondents have a filter system installed for their water supply, 1 has installed a UV filter system, while 8 had no cleaning or filtering system whatsoever.



The majority of people with the cleaning systems maintained them more often than annually, or less than annually but regularly.

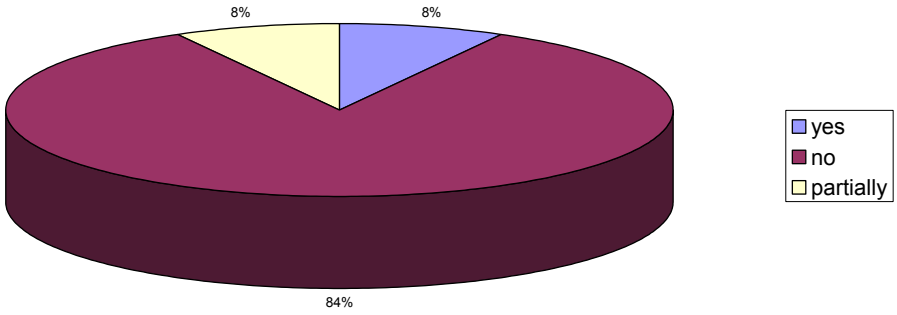
How often do you maintain or service your treatment plant/system?



93% of respondents had a storage tank. Those without a storage tank took their water straight from their bore, spring, or stream.

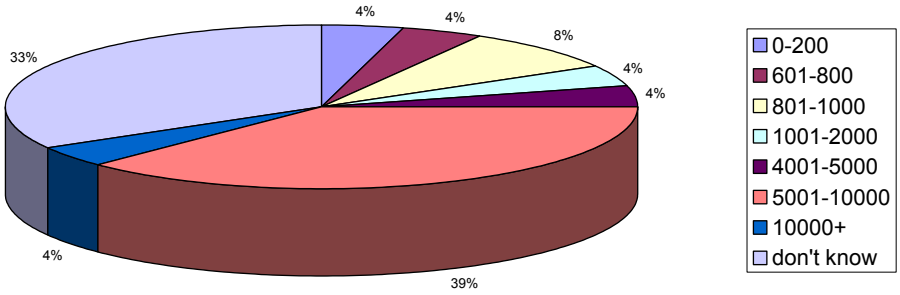
The storage tanks were mostly above ground, with 8% underground and 8% partially underground. 72% identified the pipework to their storage tank as being completely or partially underground.

Is your storage tank underground?



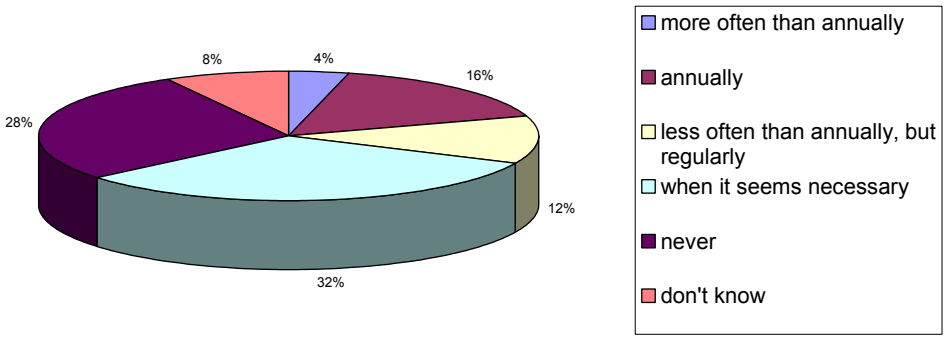
39% of those surveyed reported their tanks to hold 5001-10,000 litres. 100% of those with tanks had them securely covered so that birds or animals and their wastes could not get in.

What size is the storage tank?(litres)



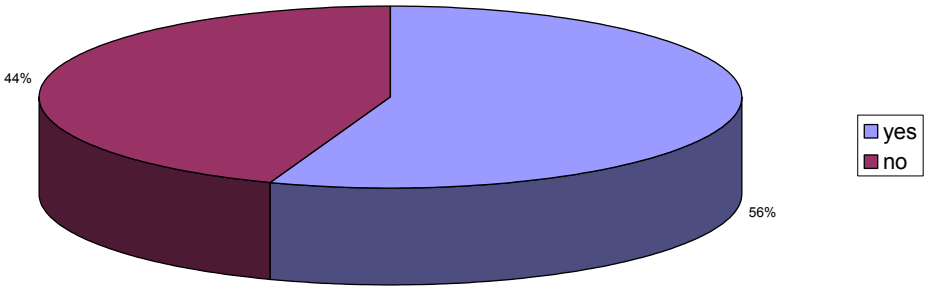
28% of respondents never clean their storage tank, with approximately another third cleaning it when it seems necessary. 12% clean their tanks regularly.

How often do you clean your storage tank?



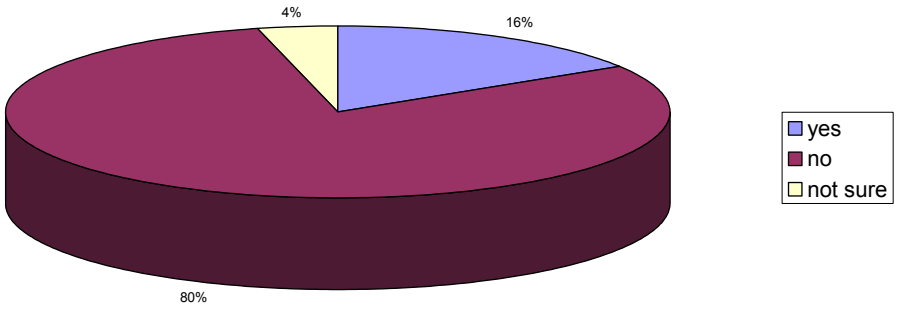
15% had experienced taste or odour problems with their drinking water. These were usually experienced after heavy rainfall or when the water level in the tank decreased significantly. One person had new paint from his roof go into his water supply. (This was dealt with by cleaning the roof and tank and approaching 'Fair Go'). 56% had had the quality of their water tested, and 76% agreed to let the council test the quality of their water should they decide to.

Have you ever had the quality of your water tested?



80% of surveyed individuals said that they would not like the council to develop a water supply system in their area. Those unsure stated that it depended on the cost of the system:

Would you like the council to develop a water supply scheme in your area?



One respondent from six said they were willing to pay higher rates for a council supply, while the others were unwilling or unsure of whether they wanted to pay for a council water supply.

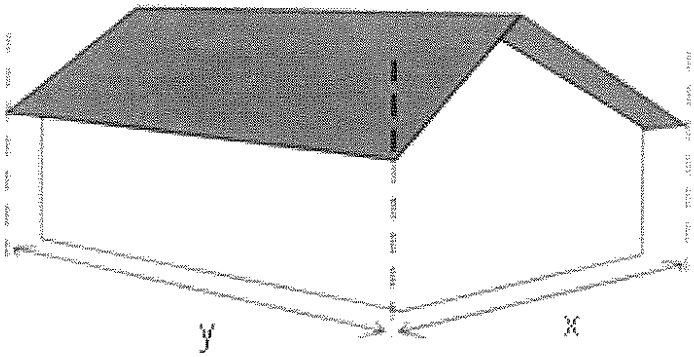
8.3 Rain Water Calculations for Individual Dwellings

Example calculation has been sourced from the Gisborne District Council

Average roof area for Township X was estimated from aerial photographs.

a. 11.5m x 18m
b. 9.5m x 17m
c. 13m x 11.5m
d. 9.5m x 15m
e. 8m x 16m

Average area of 157.7 m^2 ,for our calculation we will assume 150m^2



E.g. Amount of rain falling on a 150m^2 roof in a location with average (R) annual rainfall.
= x*y*R = A*R, where x*y=A

A	150 m^2	Losses	0 %
R	152 mm/month		
Volume	22.8 m^3	Final Volume	22.8 m$_3$

For 150m^2 the following graph show a mean monthly rainfall based on (1994-2002), consumption and tank volume. For our calculation it was assumed that the 22.7m^3 water supply tank was full in the beginning of January.

RA	150	m^2	**RA=Roof Area**
DC	250	L	**DC=Daily Consumption per person**
AO	2.76	People	**AO=Average Occupancy**
Tank	22.73	m^3	**T= Tank Volume**
WCL	6	m^3	**WCL= Water Carrier Load**

Months	Rainfall (mm)	V collected	V consumed	Short By	Tank Volume T
Jan	135	20.25	21.39	-1.14	21.59
Feb	136	20.4	19.32	1.08	22.73
Mar	180.8	27.12	21.39	5.73	22.73
Apr	160.5	24.075	20.7	3.375	22.73
May	149.9	22.485	21.39	1.095	22.73
Jun	164.6	24.69	20.7	3.99	22.73
Jul	207.2	31.08	21.39	9.69	22.73
Aug	142.1	21.315	21.39	-0.075	22.655
Sep	140.8	21.12	20.7	0.42	22.73
Oct	137.1	20.565	21.39	-0.825	21.905
Nov	127	19.05	20.7	-1.65	21.08
Dec	142	21.3	21.39	-0.09	22.64

Mean monthly rainfall based on (1994-2002), Volume collected, Volume consumed, Shortage and Tank Volume

Please note these figures are for the Gisborne Region and are only provided as an example (see Appendix 8.4 for Hauraki Rainfall Data).

8.4 Hauraki Rainfall Data

8.4.1 Ngatea Rainfall Data

Ngatea Monthly Rainfall Haywards Road (to 1999). HDC Depot (2000 on)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Totals
1993	36.0	28.5	95.0	50.0	123.0	181.5	8.0	111.0	58.0	37.0	100.0	28.5	857
1994	81.0	47.5	51.5	64.0	78.0	116.0	155.0	100.5	153.0	112.5	30.0	26.5	1016
1995	37.0	71.0	196.5	245.5	88.5	181.0	203.5	74.0	73.0	94.0	136.5	128.5	1529
1996	29.5	89.5	88.5	227.5	82.0	166.5	137.5	147.0	149.0	34.0	72.5	222.0	1446
1997	4.5	51.0	195.0	58.0	97.5	138.5	64.5	65.5	221.5	61.0	39.0	49.0	1045
1998	12.0	97.0	67.0	48.0	56.5	97.0	299.0	104.0	48.0	100.0	85.0	89.0	1103
1999	81.0	28.0	81.0	91.0	45.0	94.5	142.0	132.0	88.0	53.0	206.5	109.5	1152
2000	60.0	11.5	52.5	171.0	85.0	75.5	154.5	114.0	97.5	48.0	96.5	79.0	1045
2001	16.5	156.5	49.0	169.0	165.5	50.0	74.5	121.0	47.5	134.0	114.0	177.0	1275
2002	117.0	39.5	50.5	62.0	61.0	168.5	135.0	79.0	75.5	73.0	34.5	54.0	950
2003	110.0	105.0	102.0	134.0	73.0	124.5	101.5	58.5	155.0	107.0	36.5	111.5	1219
2004	98.5	230.0	11.5	21.0	175.5	106.5	120.5	112.0	119.0	80.0	56.0	130.5	1261
2005	10.0												10
Ave.	47	80	87	112	94	125	133	102	107	78	84	100	1141
Max	117	230	197	246	176	182	299	147	222	134	207	222	1529
Min.	5	12	12	21	45	50	8	59	48	34	30	27	857

8.4.2 Te Aroha Rainfall Data

TE AROHA, probably slightly higher than Paeroa

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1985	106	183	189	63	84	194	75	88	109	57	157	115	1420
1986	153	64	45	44	75	62	188	123	75	130	48	30	1037
1987	76	42	297	105	92	77	150	83	110	115	99	124	1370
1988	5	170	281	38	134	107	171	173	82	134	91	172	1558
1989	139	70	57	54	123	156	135	209	336	167	161	72	1679
1990	64	20	52	143	108	83	156	208	99	82	112	28	1155
1991	97	97	45	127	33	66	157	201	133	104	78	69	1207
1992	125	105	37	74	92	89	163	196	102	214	93	128	1418
1993	23	36	77	89	107	173	15	74	20	23	96	42	775
1994	79	63	43	108	64	102	211	111	168	134	70	48	1201
1995	21	68	120	229	97	137	202	67	71	96	124	102	1334
1996	36	110	102	172	82	253	141	150	119	54	73	202	1494
1997	30	51	84	43	86	155	47	86	162	92	66	104	1006
1998	13	98	78	45	112	103	282	143	62	106	137	102	1281
1999	105	13	41	105	42	111	141	80	154	34	169	67	1062
2000	58	7	48	134	58	149	236	134	138	54	80	84	1180
2001	20.5	126	60	104	177	41	74	91.5	106.5	148	142	287	1377.5
2002	198	31	55.5	63	103.5	240.5	208	88.5	75	77.5	90.5	79.5	1310.5
2003	155.5	198	89	110.5	53	106	89.5	59.5	162	102	62.5	251.5	1439
2004	41.5	199	13	34	112.5	87	85	104.5	118	111	58	136	1099.5
2005	45.5	35.5	0	0	0	0	0	0	0	0	0	0	81
Mean	76	86	87	88	86	114	132	116	109	97	90	107	1234
Hi	198	199	297	229	177	253	282	228	336	214	169	287	1679
Lo	5	7	13	32	33	41	15	29	20	23	25	28	775