Spring capping in the Peruvian highlands

by Kate Wedgwood and Jamie Bartram

An evaluation of the facilities installed under Peru's ongoing National Plan for Rural Water Supply, which began in the 1960s, has shown that by simply capping and protecting springs, clean water can be supplied at low cost.

PERU HAS A surface area of 1 285 216km^2 and, in 1990, had an estimated population of 22.3 million. Peru is divided administratively into 25 Departments, and geographically into three distinct areas: the extremely arid Pacific coast which, although accounting for only eleven per cent of Peru's land area, contains 53 per cent of the population (including Lima, which has a population of around 6 million); the Andean highlands, running the length of the country, which comprise more that 25 per cent of the area of the country and contain 36 per cent of the population; and the Amazon jungle region, to the east of the Andes, which accounts for almost two-thirds of Peru's area but only 11 per cent of the population. Seventy per cent of the population live in areas classified as urban, and 30 per cent in rural areas.

Peru has mixed administrative arrangements for water and sanitation services. The Directorate of Basic Rural Sanitation (DISABAR), part of the Ministry of Health, has overall responsibility for the provision of these services to the rural sector, which is defined as those communities with a population of less than 2000. The Peruvian National Plan for Rural Water Supply began in 1962 and since then over 2000 water supplies have been constructed. Several major agencies have been involved in these projects. The provision of water supply has tended to concentrate on communities with populations in the range of 200-2000, mainly because communities of this size have traditionally been the stated beneficiary of external funders. Examples include the International Development Bank (IDB), which funded the construction of 796 water supplies in communities of between 400 and 2000 inhabitants, and USAID which funded the construction of 1041 water supplies in communities of between 200 and 500 people.

This unprotected spring could supply the community with clean, safe water quite cheaply if it was capped.

The systems which supply water to the rural population include protected spring sources fed by gravity without treatment, surface water sources (with and without treatment), and pumped systems from wells or springs. Where possible, the emphasis of the National Plan has been on spring capping as a relatively cheap means of providing high-quality water. As a rule of thumb DISABAR was estimating the cost of construction at approximately US$1000 per kilometre of conduction line (the pipe between the spring and the reservoir) and was willing to cap springs involving conduction lines of up to five kilometres, rather than use closer surface sources, because of the high cost of building treatment works and the inherent problems of operation and maintenance.

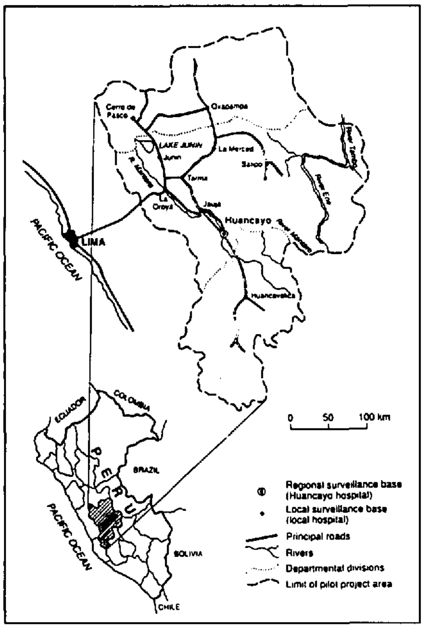
Starting over

Under Peruvian law there are provisions for the protection of drinking-water sources, the treatment of drinking water and the surveillance of drinking-water quality. Although there was a Peruvian Ministry of Health which had launched a water-surveillance initiative in the 1940s it lost momentum, especially in the rural sector, as construction took precedence over quality control. In 1985, however, a rural water surveillance programme was initiated in an attempt to fulfil the World Health Organization's *Guidelines for Drinking Water Quality*, in particular Volume 3 for small community supplies.[1] The programme was promoted and supported by the World Health Organization and funded by the UK Overseas Development Administration.

Work began on a pilot project in the rural areas of the central Andean region, comprising the Departments of Junin, Pasco, and Huancavelica (see map). Surveillance activities started with a diagnostic study of all piped rural water supply systems in the pilot region. In effect this was the first major evaluation of the water supplies constructed under the National Plan for Rural Water Supply.

The majority of the population in the pilot region is dispersed, with concentrations in the fertile Mantaro valley agricultural system, in the mining and smelting centres, and on the important trading routes (see map). The water supply systems for rural communities are small and mainly of the simple gravity type, as presented in Table 1.

Of the simple gravity systems in use, 74 per cent are capped springs. The remainder are either unprotected springs or surface water sources. A simple and cost-effective improvement to the quality of water supplied could readily be made by protecting existing unprotected spring sources.



Map of the pilot project area in Peru.

The direct distribution of contaminated surface water can be avoided either by building a treatment plant or by piping uncontaminated water from the most appropriate available source. If the capacity for constructing, operating, and maintaining both options exists, the cheapest course of action will be chosen.

Many of the gravity systems from protected spring sources comprise only a capped spring, a conduction line, and domestic connections leading directly from this. These systems had relatively few problems. Operation and maintenance requirements are both fewer and simpler than for other types of system. The main problems with the conduction line are breakages, usually a result of inadequate backfill after construction or subsequent excavation (often by the roadside, where soil has been removed to make adobe bricks). More commonly problems occur in break-pressure boxes, air valves, and purge valves in longer conduction lines.

Water storage

In most of these gravity systems in the pilot region the spring's yield is less than is needed and storage is necessary, so a reservoir is a normal component of these systems. Reservoir structures were generally adequate, but often unhygienic. The lids of the reservoirs and valve boxes were rarely secured and, in the former case, often dirty. Ventilators, a common feature of these reservoirs, were usually unprotected by a screen and often broken because they were made of plastic pipe. Valve boxes were frequently inundated with water, causing the rapid deterioration of submerged valves.

During the development of the diagnostic survey, five key health-affecting indicators of the quality of the water supply service were defined:[2]

Coverage Percentage of the total population served, and by what means: tap, standpipe, well, etc.

Continuity Hours per day and days per year that water is supplied.

Quantity Volume per capita per day supplied for domestic use.

Quality Classified on faecal contamination and the results of sanitary inspections.

Cost Tariff paid per month for domestic use.

In 1984, DISABAR claimed a rural coverage of 54.5 per cent in the pilot region. This figure appears to refer to the percentage of communities in a given size range, however, rather than the population actually supplied with water. No account was taken of the population living in communities of less than 200 inhabitants, where coverage was assumed to be zero.

The diagnostic survey showed an average coverage within communities with a water supply of only 56 per cent. Even this figure represented only the proportion of households with a domestic connection or access to a public standpipe, and took no account of water shortages or discontinuity of service. Increased coverage is clearly a very high priority. New strategies should include both the construction of new systems and the expansion of existing systems. An analysis of water usage and availability showed that the quantity of water available from the source was always adequate. Alternative strategies should also address the specific problems of the dispersed population.

With respect to continuity of service, the simple gravity supplies from protected springs tended to be free of problems, providing year-round service with no interruption of flow at the tap. Some springs demonstrated a seasonal variation in continuity of service as a result of a natural reduction of source volume.

An analysis of the amount of water actually used by householders proved difficult, and so was of limited use as an indicator of either domestic needs or the acceptability of the service. A common problem was the distortion of the figures as a result of the demand for irrigation water in the eight-month dry season. Both source waters and domestic connections were used for irrigation purposes. Apparent domestic consumption was thus often extremely high. Continuity and effective coverage also suffered as water was drained to houses connected to lower parts of the distribution network. The water administrative committees still need both training and supervision though, and public awareness campaigns will improve this situation markedly.

Table 1. Population served and percentage coverage by supply type

System type	*Number of systems*	*Population served*	*Rural population with water supply served by system type (%)*
Simple, gravity	273	191 898	84
Gravity with treatment	25	25 924	11
Simple, pumped	9	10 895	5
Total	307	228 717	100

Table 2. Water quality by supply type in the central region of Peru, 1986-7

System type	*Number existing*	*Percentage of systems supplying water of quality**			
		A	*B*	*C*	*D*
Simple, gravity	273	23	43	17	18
Gravity with treatment	25	4	8	12	76
Pumped	9	11	22	22	44
Total	307	21	39	17	23

*Category based on worst result from reservoir or distribution network during a single sampling visit.

The majority of the simple gravity systems were found to be supplying water of reasonable quality as indicated in Table 2. The faecal coliform classification was applied to grade piped supplies in the following way:

Grade A 0 faecal coliforms/100ml in all samples in one distribution system on one sampling visit: i.e. conforms to WHO bacteriological guidelines.

Grade B 1-10 faecal coliforms/100ml in all or any samples on one sampling visit: i.e. low-level, often sporadic, contamination.

Grade C 11-50 faecal coliforms/100ml in all or any samples on one sampling visit: i.e. medium contamination with significant water-borne disease risk.

Grade D >50 faecal coliforms/100ml in all or any samples on one sampling visit: i.e. grossly contaminated with high water-borne disease risk.

Paradoxically, the worst-quality supplies were typically those systems with treatment. Treatment almost invariably consisted of sedimentation and slow-sand filtration. Because of the repeated inadequacies in the construction, operation, and maintenance of the treatment systems, 76 per cent of those evaluated were supplying grossly contaminated water (Grade D).[3] Pumped systems also had a high frequency of contamination, despite generally superior source water. The rapid deterioration in quality often occurred because of zero internal pressure in the distribution network for prolonged periods; this was caused by restricted pumping regimes, which permitted an ingress of contaminants. In contrast, of the 273 simple gravity systems, only 17 per cent were grossly contaminated.

All communities that received systems constructed by DISABAR in the pilot region (70 per cent) had been obliged to form an administrative committee responsible for organizing the operation and maintenance of the water supply and the collection of a monthly tariff. The administration of the systems was assessed and summarized in Table 3.

During the diagnostic survey the surveillance teams evaluated each community's interest in improving their water supply. Overall, 97 per cent of communities were willing to provide labour and 39 per cent were also willing to contribute financially.

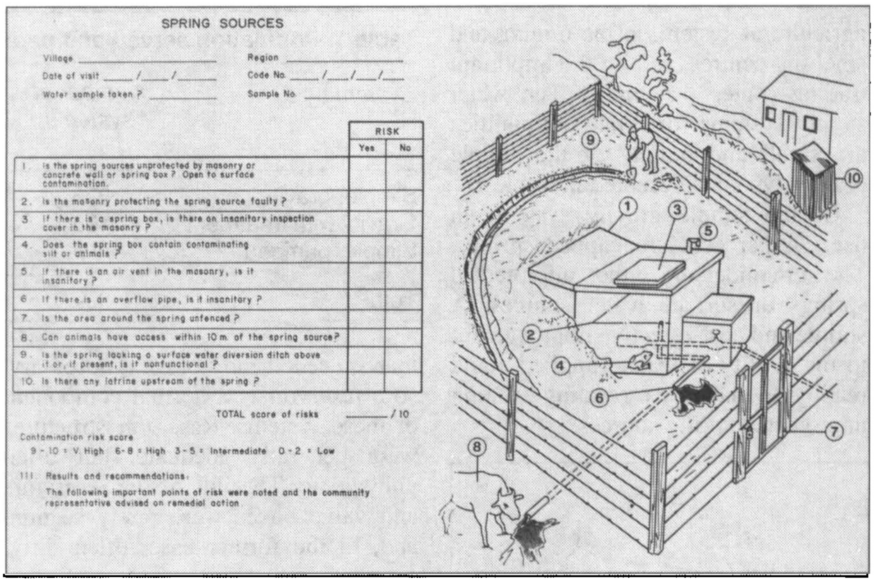


Figure 1. A sanitary-survey form for spring sources.

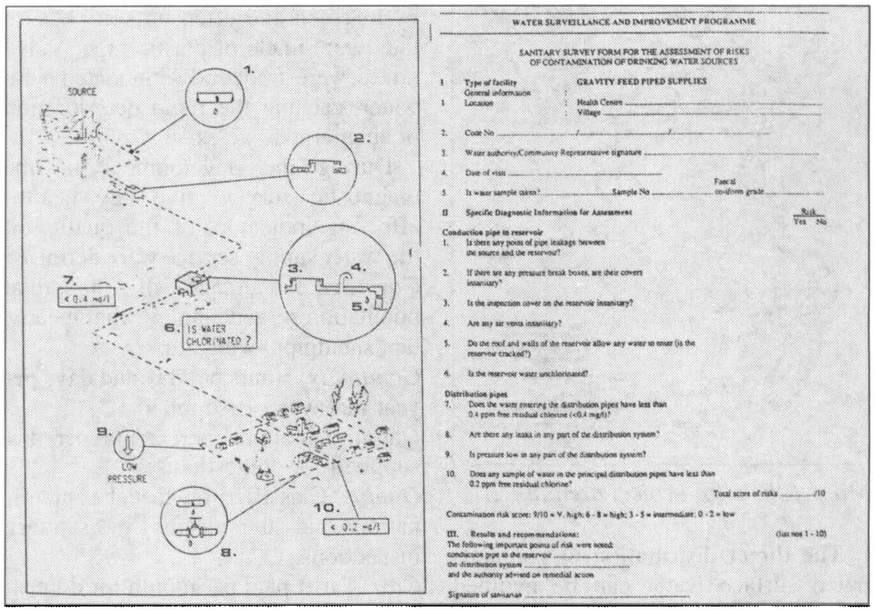


Figure 2. A sanitary-survey form for a gravity-fed piped distribution system.

The risk of contamination was assessed by sanitary inspection. Sanitary surveys were designed for each of the main types of water sources and supplies. The objective was to establish a reporting system which could be completed rapidly and accurately on site at the same time that sampling and water quality analysis are carried out. The report form is intended to serve several purposes as follows:

- Identify the potential sources of contamination.
- Quantify the risk level of each facility.
- Facilitate the systematic and standardized inspection of water supply systems.
- Provide clear guidance for the user, and a record for the local surveillance team, as to the remedial action required.

To meet these needs, double-page forms were developed and tested in the pilot region. These forms have now been refined through use elsewhere. Simplified examples are shown in Figures 1 and 2. While on site the sanitary technician completes the checklist with the help of the operator, and then totals the number of risk points to give a score in the range 0 (no risk) to 10 (very high risk). After completing the checklist, the sanitary technician circles each of the points of risk on the diagram. The diagram is then separated from the report form and given to the community representative, together with instructions and explanations of what needs to be done to improve the system.

Table 3. Indicators of water supply administration in the pilot region, 1986-7

Indicator	*Communities with indicator (%)*
Administrative committees	93
Operator	67
Access to tools	43
Operator trained	43
Tariff collected	71

Spring capping provided a robust, appropriate water supply.

The collected data was analysed, and the frequency of occurrence of the most common risk features found in gravity-fed systems from protected spring sources without treatment are summarized in Table 4.

It was concluded from the diagnostic survey that the faults found in simple gravity supplies from protected springs showed the need to promote simple, community-based repair and maintenance strategies rather than occasional and expensive rehabilitations.

Spring capping was found to be a very robust, appropriate water supply technology for the Andes. In spite of the various problems discussed above, many of these supplies are well over twenty years old and are still in good working order, supplying water of acceptable quality at a very low cost.

References

1. World Health Organization, *Guidelines for Drinking Water Quality, Volume 3: Drinking water quality control in small community supplies*, WHO, Geneva, 1985.
2. Lloyd, B. and Helmer, R., 'The development and evaluation of a water surveillance and improvement programme for Peru', *Pro. of the Int. Con. on Resource Mobilisation for Drinking Water Supply in Developing Nations, San Juan, Puerto Rico, May 1987.*
3. Lloyd, B., Pardón, M. and Bartram, J., 'Improved piped water supplies in Peru', *Waterlines* 7(3), pp.24-6, 1989.

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Table 4. Frequency of occurrence of twelve common risk factors in gravity-fed systems from protected spring sources without treatment

Points of risk	*Systems with fault (%)*
No lock on reservoir	98
Chlorination not practised	91
Leaks in pipe from source to reservoir	88
No fence around spring source	87
Leaks in pipe from reservoir to distribution	87
No disinfection equipment	85
No ditch around spring source preventing surface water ingress	83
No lock on spring catchment	83
Faecal contamination near catchment	75
No sanitary lid on spring box	55
No concrete cover behind spring box	47
No sanitary lid on reservoir	42