Water for the World

Selecting a Source of Surface Water
Technical Note No. RWS. 1.P.3

The success of a water project depends on the suitability of the water source that is chosen to serve the community. The selection of the most appropriate source is very important and requires that all available water sources that could serve the community be identified, and the most appropriate source be selected. A source should be selected only if (a) it meets the needs of the users, (b) is easily accessible to them, and (c) can be developed at an affordable cost.

This technical note suggests guidelines for choosing the most appropriate surface water source for a community. It describes methods for measuring the quantity of water available from a surface source, and establishes four priorities for source selection that will help ensure the selection of the best source at the lowest development cost.

Useful Definitions

DISINFECTION - Destruction of harmful micro-organisms present in water, through physical (such as boiling) or chemical (such as chlorination) means.

HEAD - Difference in water level between the inflow and outflow ends of a water system.

HYDRAULIC RAM - A self-powered pump which uses the energy of falling water to lift some of this water to a level above the original source.

POTABLE WATER - Water that is free from harmful contaminants, is aesthetically appealing, and is good for drinking.

RECHARGE - Natural process by which quantities of water are added to a source to form a balance between inflow and outflow of water.

WATER BALANCE - Balance of input and output of water within a given defined hydrological area such as a pond or lake, taking into account changes caused by storage.

Determining Quantity of Water Available

In considering a water source, you must first find out how much water it yields, whether it provides enough water to meet community needs and whether it is reliable during the entire year.

Springs. To determine the suitability of a spring, it is necessary to know how much water it will yield, and how well it will keep up its flow in dry weather.

The yield is measured by a very simple method. First, channel the spring's flow into a small, hollowed-out collection basin that is dammed at one end. Make sure that the basin collects all available flow. Place an overflow pipe through the dam so that the collected water flows freely through the pipe, as shown in Figure 1. Make certain there is no

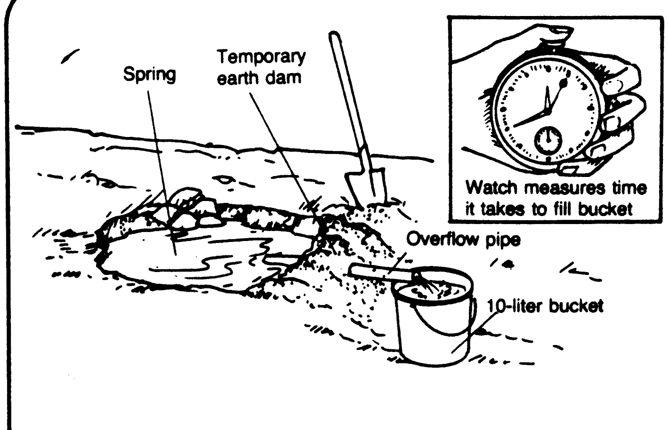

Figure 1. Measuring Spring Flow

leakage around the pipe. Then, put a bucket of a known volume (for example, a 10-liter bucket) under the pipe to catch the flow. With a watch, measure the amount of time it takes for the bucket to fill. Divide the volume of water by the amount of time to find the rate of flow in liters per minute. For example, if the 10-liter bucket fills in 45 seconds, the rate of flow is:

$$\frac{10 \text{ liters}}{45 \text{ seconds}} = 0.22 \text{ liters/second}$$

0.22 liters/second x 60 seconds/minute = 13.2 liters/minute

It is then easy to determine the volume of water available during a 24-hour period. Multiply the number of liters per minute by 60 minutes per hour to find liters per hour. For example:

13.2 liters/minute x 60 minutes = 792 liters/hour

Then, take the flow in liters per hour and multiply it by 24 hours per day to find the daily flow. For example:

792 liters/hour x 24 hours/day = 19008 liters per day

Compare this amount to the daily needs of the community. The daily need is computed by multiplying the number of users by the number of liters each person will use in one day. For example, if there are 300 people using 40 liters per day, the daily water usage is 12000 liters. A spring with a daily flow of 19008 liters and a storage tank would be more than enough to meet the needs of a community of this size.

Ponds, Lakes and Reservoirs. The amount of water available in a small pond, lake or reservoir can be roughly estimated by a simple method. An example to follow is shown in Figure 2.

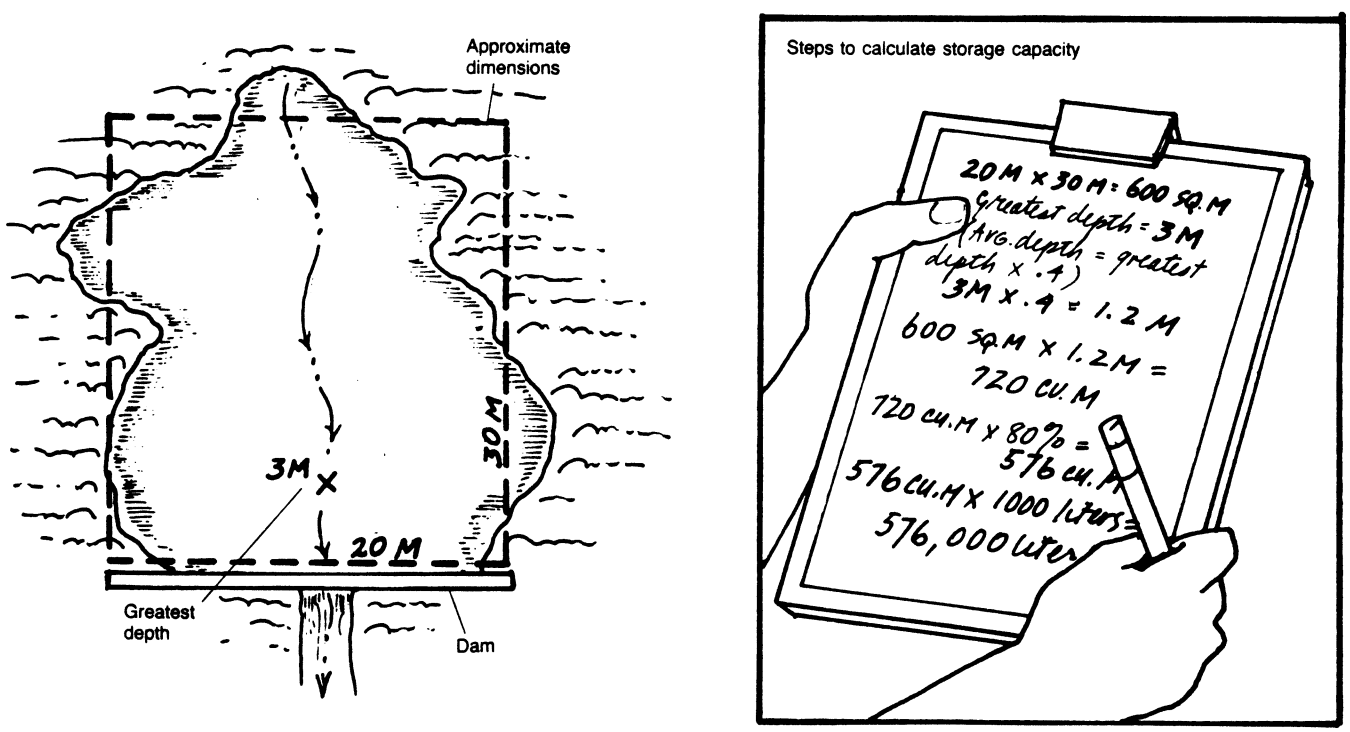

Figure 2. Estimating Storage Capacity of Small Lake or Pond

1. Lay out a rectangular shape around the body of water approximately its size.

2. Measure the length and width of the rectangle and multiply the two numbers to find the area of the rectangle in square meters. For example, if the length is 30m and the width 20m, the area is $600m^2$.

3. The depth of the source should be measured at the deepest point and the average depth calculated. The average depth is found by multiplying the greatest depth in meters by 0.4. If the deepest point in the pond measures 3m, the average depth is 3m x 0.4 = 1.2m.

4. The amount of water in the source is measured in cubic meters and is calculated by multiplying the area (m^2) by the average depth (m). In the example, the area is 600m and the average depth 1.2m. The volume of water is $600m^2$ x 1.2m = $720m^3$.

5. A basic rule to follow is that the volume of water available is generally about 80 percent of the total volume of water in the pond or lake. The other 20 percent is usually lost through evaporation, transpira tion, and seepage. To find the volume of water available for use, multiply the total volume of water by 80 per cent. For example, .80 x $720m^3$ = $576m^3$.

6. There are 1000 liters of water per cubic meter (1000 liters = $1m^3$). In the example, the water available for use in liters is:

$576m^3$ x 1000 = 576000 liters.

Compare the estimated amount of water available to the amount needed by the community and estimate how many months the source will provide water for a community without recharge. This determination will assist in planning for times when there is no rain. If possible, a source should contain at least a six-month storage supply. To refine further the estimate of the source's yield, find out its history during the wet and dry seasons. Note any major fluctuations in water level and be prepared for them when planning to develop the source.

For example, if 100 people use 40 liters per day each, or 4000 liters total, we can determine their monthly water usage and the number of months the pond will supply sufficient water. To do this, multiply the total daily usage by 30 days per month:

4000 liters x 30 days/month = 120000 liters/month

Then divide the total number of liters available by the number of liters used in a month to find the number of months the source will last without recharge:

$$\frac{576000 \text{ liters}}{120000 \text{ liters/month}} = 4.8 \text{ months}$$

In the example, the source would supply storage for approximately five months without normal recharge. That is, unless there were rain, the pond would dry up in five months. When considering pond or lake development, it is necessary to take into account rainfall and recharge rates to make sure the source is suitable.

Rivers and Streams. Simple methods are available for determining the flow of water in a stream or river. For smaller streams, the same method as for spring flow can be used. That is, a dam with an overflow pipe can be built and the flow can be found by seeing how long it takes for a bucket of known volume to fill with water.

There is another method for determining flow in small streams with slightly greater flow. It is called the V-notch method. A V-shaped notch with a 90° angle is cut out of a flat piece of metal or wood and placed in the middle of a dam so water flows through the notch as shown in Figure 3. A gauging rod is placed in the stream 2 to 3m upstream from the dam. The zero point on the rod must be level with the bottom of the notch. The depth of the water from the bottom of the notch, the zero point, to the water level can be read from the gauge. Table 1 gives the flow per second for a given height. This information will help determine the amount of water available for an intake in a stream or river.

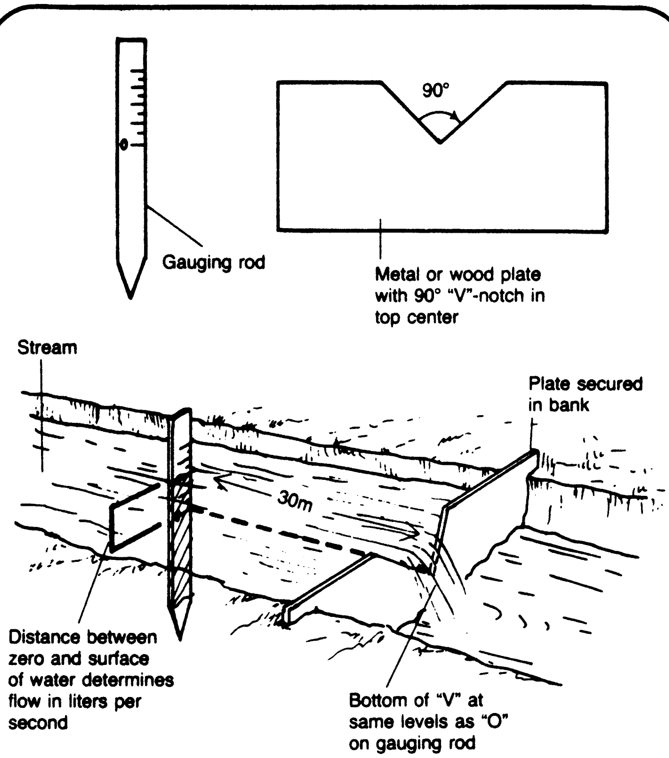

Figure 3. Measuring Stream Flow

If the flow is too great to use the V-notch, there is another, less accurate, method that can be used. This method is not nearly as accurate as the others and should be used only when measuring flow in larger streams. Find a straight, wide stretch of a stream and measure a length along the bank. Place a stake at each end of the measured distance as shown in Figure 4. Throw a floating object into the stream at the first stick and time how long it takes for the object to reach the

Table 1. Flow Over a 90° V-Notch

Height of Water (mm)	Flow (liters/second)
50	0.8
60	1.2
70	1.9
80	2.6
90	3.4
100	4.5
110	5.6
120	7.0
130	8.6
140	10.3
150	12.3

second stick. Repeat this test three times and take the average. The flow in liters per second is calculated using the following formula:

$$850 \times \text{measured length} \times \text{width of the stream} \times \frac{\text{average depth}}{\text{average time}}$$

For example, to measure the flow of a stream 1m wide with an average depth of 0.3m, place two sticks on the bank approximately 3m apart. Throw a floating object into the middle of the stream at the first stake and measure how long it takes to travel the 3m distance. Take the measurement three times. Assuming the object takes an average of 20 seconds to float 3m, use the equation to deter mine river flow:

$$850 \times 3\text{m} \times 1\text{m} \times \frac{.3\text{m}}{20} = 38.25 \text{ liters/second}$$

To find out if the flow will be sufficient, determine the daily demand for water and the volume of available water. The flow in liters per second can be converted to flow per day by using the following formula:

liters/second x 60 = liters/minute;
liters/minute x 60 = liters/per hour;
liters/hour x 24 = liters/day.

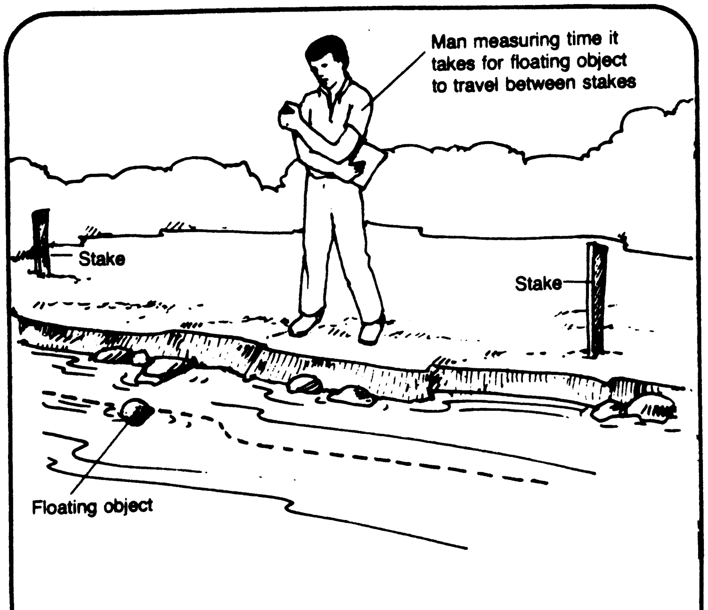

Figure 4. Measuring Large Stream Flow

Rain Catchments

When considering a rain catchment as a source for a water supply, first determine individual needs. This is done by multiplying the number of people in the family that will use the system by 15 liters per person. If there are six people in a family using 15 liters of water per person per day, the total demand for water is 90 liters:

15 liters/person/day x 6 persons = 90 liters/day.

The second step is to figure out how much water will be available. Determine the area of the catchment area by multiplying the length of the roof by the width. The width is the length of the base of the triangle formed by the roof. For example, if the length of the roof is 8m and the width is 6m, then the area of the roof is $48m^2$.

Next, determine the amount of annual rainfall for the region. This should be available from a local government agency, a weather station or an airport. Multiply the amount of annual rainfall by the area of the roof catchment to find the amount of water available for consumption. For example, assume that 750mm, or .75m, of rain falls on a $48m^2$ catchment area. The quantity of water available for use is $.75m \times 48m^2 = 36m^3$. To convert $36m^3$ to liters, multiply by 1000:

36 x 1000 = 36000 liters/year.

Not quite all the water will be collected. Some splashes to the ground and some evaporates. For planning purposes, assume that 20 percent of the water is lost. Then the amount of water actually available is 28800 liters. This is calculated by multiplying the amount available, 36000 liters, by 0.80:

36000 liters x .80 = 28800 liters.

To make the numbers easier to work with, divide the total quantity available either by 12 to get liters per month or by 365 to get liters per day:

$$\frac{28800 \text{ liters/year}}{12 \text{ months/year}} = 2400 \text{ liters/month}$$

$$\frac{28800 \text{ liters/year}}{365 \text{ days/year}} = 79 \text{ liters/day}$$

A cistern must be constructed to store the water collected by the catchment. For information about storage see "Methods of Storing Water," RWS.5.M, and "Determining the Need for Water Storage," RWS.5.P.1.

Compare the total available quantity to the demand for water and determine if family needs can be met using a roof catchment system. Each person should have 15 liters per day available, but in some cases demand for water from catchments may be less than 15 liters. If the quantity available ranges between 10 and 15 liters per person, the system is suitable.

Priorities for Source Selection

The quantity of water available from surface sources can now be determined. Quantity is an important factor but it is not the only one. A suitable source must provide good quality water, and it must be reliable. Another important factor is that water should be available to the user at the lowest possible cost.

When planning to select a suitable source, it is useful to have a set of guidelines. The first guideline discussed here is sufficient water quantity. If several sources offer adequate quantity, a choice must be made among sources. Table 2 lists priorities to consider when choosing a source.

Table 2. Priorities for Surface Water Source Selection

Priority	System
First	No treatment or pumping required
Second	No treatment but pumping is required
Third	Some treatment but no pumping is required
Fourth	Both treatment and pumping are required

These priorities are guidelines for selecting the most appropriate source among several alternative methods of surface water development. The priorities are established in order of ease of construction, maintenance, and financing of the system. Where no treatment or pumping is required, a system is easier to develop, operate and maintain. Moreover, the development costs should be lower than for systems requiring treatment and pumping. Once treatment and pumping are added to a water system, costs rise and a program for operation and maintenance must be established to ensure constant operation. These extra costs could make the development of the project difficult for a rural community. When following the basic guidelines, keep in mind other factors such as community preferences and available community resources.

No Treatment; No Pumping. A water source which supplies abundant water needing no treatment that can be delivered to the user by a gravity system should be the first source considered. Because no treatment or pumping is required, the cost of developing, operating and maintaining the system is relatively low.

If a spring of sufficient capacity is available in, or near, the community, it could prove to be the best source. Water from a protected spring generally needs no treatment. An initial disinfection applied after the source is protected will be sufficient to ensure good water quality. If springs are found in hilly areas, they can easily be developed to supply a community with water through a gravity flow system. Water from the spring flows downhill into storage and then to the distribution system.

Care must be taken to ensure that there is an adequate head so water will reach the users. Head is the difference in water levels between inflow and outflow ends and is an important concept in developing water systems. The possibility of loss of water pressure due to insufficient head is an important consideration in determining the suitability of a source. When planning to use any surface source, especially a gravity flow source where water is piped, see "Designing a System of Gravity Flow," RWS.4.D.1.

A stream or river in a highland region with few inhabitants is another source which probably will require neither treatment nor pumping. In an area where not many people live, fecal contamination is not a likely problem and treatment will not be necessary. In a hilly region, the water intake can be located at a higher elevation than the storage tank and the community. This will allow use of a gravity flow distribution system if head is sufficient. Costs should be low, but higher than for a spring because of the task of constructing a river intake. Maintenance should be simple.

Rivers and springs that do not require pumping or treatment are good sources of water for a community supply. Water from both sources is often cool and tastes good to the users. Generally, the source is accessible and is one that the community is accustomed to using. A project using water from these sources will normally be accepted by the community, and will offer them good water at low cost.

No Treatment; Pumping Required. When a first priority source is either not available or is inadequate, consideration should be given to a source that needs no treatment but requires pumping. Treatment can be very expensive and requires special skills, equipment, and a continued supply of treatment chemicals except where only simple settling is needed.

Pumping devices, on the other hand, can be simple, easy to install and inexpensive, such as hand pumps. They can also be quite complicated and expensive to operate and maintain, as is true of power pumps. Whenever any pump is installed, trained maintenance people with access to spare parts will be needed. Mechanical pumps require energy and either electric power or petroleum to operate.

In some cases, water from a natural lake or pond may not need treatment for use as a drinking source, especially if it is located away from uninhabited upland areas. Thorough testing of the water should be done before using it without treatment.

A river or stream is another source of water that possibly can be pumped without treatment. Several alternatives exist. A mechanical pump can easily be installed in a mountain stream where a gravity flow system is not feasible. Where there is sufficient fall and volume of water in the stream, an inexpensive hydraulic ram can be used to lift water to a storage tank.

An infiltration well or infiltration gallery may also provide water that needs no treatment. Infiltration intakes are located on the banks of streams and rivers. The stream water that enters them flows through the ground and is filtered. If properly planned and designed, infiltration wells and galleries can provide water needing no treatment.

A hand pump can be installed on the infiltration well and on the storage well of infiltration galleries, if water is to be used at the source. If water distribution is necessary, a windmill or fuel-powered pump can be installed.

Some Treatment; No Pumping Required. In some circumstances, the only surface sources available to a community will need treatment. Since treatment can be relatively expensive, a source which requires some treatment but no pumping should be the next source considered.

Rain catchments offer a relatively inexpensive method for providing water to individual users. Water from a rain catchment requires treatment because dirt, bird and animal excreta and other contaminants collect on the roofs of houses between rainfalls. During a rainfall, the contaminants are washed into gutters and pipes and then into the water collection cistern. To be safe, this water must be filtered and disinfected (see "Methods of Water Treatment," RWS.3.M). Rain catchments offer a variable yield and should only be considered where rainfall is adequate. Where rainfall is abundant, the system should prove reliable.

A contaminated river or stream in a hilly area is well-suited for a gravity flow system. Where treatment is necessary, water will flow through the intake, through treatment and into storage. This system may be very expensive due to construction and continuing treatment costs.

The source requiring the least treatment will cost less to develop. The amount of treatment a source will need must be determined before a source is selected.

Treatment and Pumping Required. Of all the alternatives mentioned, the most expensive is that which requires both treatment and pumping. Ponds, lakes and most streams fit into this category. Water from ponds and lakes usually must be pumped and usually requires treatment. If a pond is not exposed to fecal contamination, treatment may be a very simple process and not very costly.

A pond or lake can be a very good source of abundant and accessible water and may be the only source available to a community. With proper management of the watershed and with adequate treatment, a pond or lake will be a good source. An efficient system of operation and maintenance must also be established to ensure continued functioning of the system. Costs for this kind of system are likely to be high.

Small community ponds, especially where manmade, usually are highly contaminated from waste and contaminated run-off. Use of a contaminated community pond is risky and treatment must be very good to make the water potable. Water from this type of pond should not be used unless another good alternative does not exist.

Direct use of water from a river or stream usually requires that water be pumped from the source and treated before it is used by the community. Water from rivers and streams in lowland areas is especially likely to be contaminated. Water quality in rivers and streams should always be questioned because there are likely to be sources of contamination upstream. Only in mountain streams or where infiltration galleries are used is stream water likely to be good without treatment.

Direct use of water from a river or stream usually requires that water be pumped from the source and treated before it is used by the community. Water from rivers and streams in lowland areas is especially likely to be contaminated. Water quality in rivers and streams should always be questioned because there are likely to be sources of contamination upstream. Only in mountain streams or where infiltration galleries are used is stream water likely to be good without treatment.

Technical Notes are part of a set of "Water for the World" materials produced under contract to the U.S. Agency for International Development by National Demonstration Water Project, Institute for Rural Water, and National Environmental Health Association. Artwork was done by Redwing Art Service. Technical Notes are intended to provide assistance to a broad range of people with field responsibility for village water supply and sanitation projects in the developing nations. For more detail on the purpose, organization and suggestions for use of Technical Notes, see the introductory Note in the series, titled "Using 'Water for the World' Technical Notes." Other parts of the "Water for the World" series include a comprehensive Program Manual and several Policy Perspectives. Further information on these materials may be obtained from the Development Information Center, Agency for International Development, Washington, D.C., 20523, U.S.A.