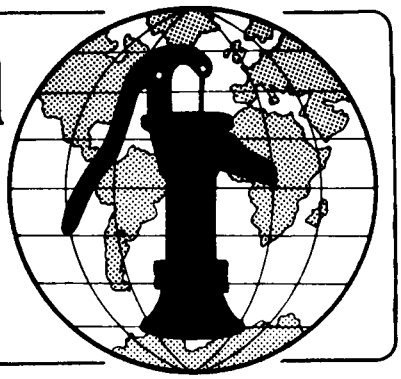
Water for the World

Operating and Maintaining Mechanical Pumps

Technical Note No. RWS. 4.0.2



Proper operation and maintenance of mechanical pumping equipment is an essential part of managing a water system. Failure to provide timely maintenance, including making minor repairs before they become major, is a primary cause of system failure.

Operation and Maintenance Activities

Operation and maintenance normally includes the following activities for all types of pumping systems:

- Keep equipment and pump house clean and painted to prevent rust or weathering.
- Keep equipment lubricated.
- Record system pressure and water use as well as preventive maintenance and repairs.
- Recognize potential mechanical problems and make adjustments before failure occurs.
- Replace failing or failed parts of equipment.
- Keep buildings, including doors and windows, in good operating condition.
- Keep records, interpet information recorded and make recommendations to management.
- Load and store chemicals, take water samples and perform tests of the water if water treatment equipment is located in pump house.

When these duties are performed regularly and correctly, major breakdowns can be avoided. The result is an overall lower cost of providing water.

Maintenance Schedule

So that no maintenance task is overlooked, a schedule should be developed showing items which need to be attended to on a daily, weekly, monthly or other routine basis. A good place to start in identifying the routine maintenance required is by reviewing the manufacturers' equipment manuals which should have been supplied with each piece of equipment. These manuals, along with the as-built plans of the pumping system, should be stored in a safe place where they are readily accessible. If the manuals are not available, they should be ordered from the supplier or manufacturer. Tables 1 and 2 show a typical maintenance record and maintenance schedule.

Equipment

Many small systems will not have the resources to provide equipment for transportation and mechanical work and thus will have to rely on people. For larger systems where equipment can be provided, a backhoe, dump truck or heavy duty pick-up, an electric generator and an air compressor would be useful.

Supplies

Rural systems are often remote from sources of repair items. It is important that either a readily available supply source be identified or spare parts and supplies kept for those items most likely to be needed. This includes grease and oil, fuses, repair clamps and such items as magnetic breakers if they are difficult to obtain. Spare bearings, pumps and motors should be kept available if at all possible.

Table 1. Preventive Maintenance Schedule

Daily:	Turn pump on/off as required.
	Check pump for excess heat in motor or bearing.
	Check controls for proper operation.
	Check water level in well.
	Check piping for leaks.
	Check condensation in pump house.
	Check chemical levels.
	Check oil level, pressure and fuel level if internal combustion engine.
	Record water and electric motor readings.
	Record system pressure.
	Record chemical residuals.
	Record unusual observations.
	Record fuel used, hours run, for internal combustion engine.
	Correct problems identified.
	Order parts which have a long delivery time.
Monthly:	Lubricate pump.
	Check amperage on electric motor.
	Report on water use for month.
Semi-annually:	Lubricate pump house door hinges.
	Close and open gate valves in pump house.
	Test blow off is furnished.
Other:	Change oil, oil filters, fuel filters in accordance with manufacturers.
	-Each fall check backup heating system.
	-Do preventive maintenance as specified by manufacturer.

Table 2. Pump House Record Keeping

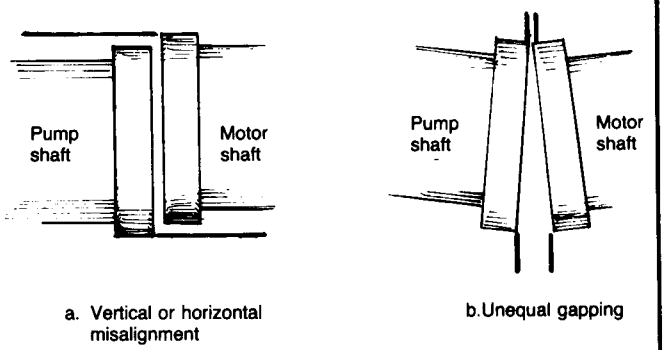
Date and Time	Pressure Reading	Water Meter Reading	Chlorine Residual	Fluoride Residual	Comments/Observations

Pump Operation

One of the most important considerations in operating a pumping plant is to keep it clean and orderly. Oil and grease should be removed, dirt swept up, and tools and parts stored in their proper places at all times. Touch up the paint to prevent rust when repairs are made and repaint on a regular basis. This not only helps to keep the plant clean but indicates a good, reliable operation.

As common a mistake as not providing sufficient oil or grease is to use too much. Do not over- oil and grease. Bearings run hotter if the grease is packed. Remove the lubricant every 6 to 12 months and replace it. Use the type of oil or grease recommended by the manufacturer.

If noise or vibration occurs, find the cause. Centrifugal pumps and motors are meant to run smoothly even at high speeds. Noise or vibration probably means there is a misalignment between the pump and motor. See Figure 1. If the situation is allowed to continue, wear and early failure will result.



a. Vertical or horizontal misalignment

b.Unequal gapping

Figure 1. Causes of Noise or Vibration

Trouble Shooting

The system should be relatively trouble free if it is properly designed and installed and maintenance instructions from the manufacturer are followed.

Unfortunately, there are no perfect pumps or pump controls. Problems will be encountered from time to time. Table 3 provides a general check chart for common problems with centrifugal pumps. Tables 4 and 5 are typical of manufacturers' trouble shooting guides for jet and submersible pumps. Problems must be methodically checked for each possible cause of trouble and corrections made. Equipment failure may be caused by something quite different than expected. The underlying cause of the problem must be identified and corrected.

Table 3. Check Chart for Centrifugal Pump Troubles

Ten Symptoms	Possible Cause of Trouble (Each number is explained below)
Pump does not deliver water. Insufficient capacity delivered.	1-2-3-4-6-11-14-16-17-22-23 2-3-4-5-6-7-8-9-10-11-14-17-20-22-23-29-30-31
Insufficient pressure developed.	5-14-16-17-20-22-29-30-31
Pump loses prime after starting.	2-3-5-6-7-8-11-12-13
Pump requires excessive power.	15-16-17-18-19-20-23-24-26-27-29-33-34-37
Stuffing box leaks excessively.	13-24-26-32-33-34-35-36-38-39-40
Packing has short life.	12-23-24-26-28-32-33-34-35-36-37-38-39-40
Pump vibrates or is noisy.	2-3-4-9-10-11-21-23-24-25-26-27-28-30-35-36-41-42-43-44-45-46-47
Bearings have short life.	24-26-27-28-35-36-41-42-43-44-45-46-47
Pump overheats and seizes up.	1-4-21-22-24-27-28-35-36-41

Explanation of Possible Causes of Trouble

Suction Troubles

1. Pump does not prime.
2. Pump or suction pipe not completely filled with liquid.
3. Suction lift too high.
4. Insufficient margin between suction pressure and vapor pressure.
5. Excessive amount of air or gas in liquid.
6. Air pocket in suction line.
7. Air leaks into suction line.
8. Air leaks into pump through stuffing boxes.
9. Foot valve too small.
10. Foot valve partially clogged.
11. Inlet of suction pipe insufficiently submerged.
12. Water-seal pipe plugged.
13. Seal cage improperly located in stuffing box preventing sealing fluid entering space to form the seal.

System Troubles

14. Speed too low.
15. Speed too high.
16. Wrong direction of rotation.
17. Total head of system higher than design head of pump.
18. Total head of system lower than pump design head.
19. Specific gravity of liquid different from design.
20. Viscosity of liquid differs from design.
21. Operation at very low capacity.
22. Parallel operation of pumps unsuitable for such operation.
23. Foreign matter in impeller.
24. Misalignment.
25. Foundations not rigid.
26. Shaft bent.
27. Rotating part rubbing on stationary part.
28. Bearings worn.
29. Wearing rings worn.
30. Impeller damaged.
31. Casing gasket defective permitting internal leakage.
32. Shaft or shaft sleeves worn or scored at the packing.
33. Packing improperly installed.
34. Incorrect type of packing for operating conditions.
35. Shaft running off center because of worn bearings or misalignment.
36. Rotor out of balance resulting in vibration.
37. Gland too tight resulting in no flow of liquid to lubricate packing.
38. Failure to provide cooling liquid to water-cooled stuffing boxes.
39. Excessive clearance at bottom of stuffing box between shaft and casing, causing packing to be forced into pump interior.
40. Dirt or grit in sealing liquid, leading to scoring of shaft or shaft sleeve.
41. Excessive thrust caused by a mechanical failure inside the pump or by the failure of the hydraulic balancing device, if any.
42. Excessive grease or oil in antifriction-bearing housing or lack of cooling, causing excessive bearing temperature.
43. Lack of lubrication.
44. Improper installation of antifriction bearings (damage during assembly, incorrect assembly or stacked bearings, or use of unmatched bearings as a pair).
45. Dirt getting into bearings.
46. Rusting of bearings due to water getting into housing.
47. Excessive cooling of water-cooled bearing resulting in condensation in the bearing housing of moisture from the atmosphere.

Table 4. Trouble Shooting Guide-Jet Pumps

Pump Will Not Start or Run

Cause of Trouble	How to Check	How to Correct
1. Blown fuse	Check to see if fuse is OK	If blown, replace with fuse of proper size
2. Low line voltage	Use voltmeter to check pressure switch or terminals nearest pump	If voltage under recommended minimum, check size of wiring from main switch on property; if OK, contact power company
3. Loose, broken, or incorrect wiring	Check wiring circuit against diagram; see that all connections are tight and that no short circuits exist because of worn insulation or crossed wire	Rewire any incorrect circuits; tighten connections, replace defective wires
4. Defective motor	Check to see that switch is closed	Repair or take to motor service station
5. Defective pressure switch	Check switch setting; excessive wear	Adjust switch settings; clean contacts with emory cloth if dirty
6. Tubing to pressure switch plugged	Remove tubing and blow through it	Clean or replace if plugged
7. Impeller or seal	Turn off power, then use screwdriver to try to turn impeller or motor	If impeller will not turn, remove housing and locate source of binding
8. Defective start capacitor	Use an ohmmeter to check resistance across capacitor; needle should jump when contact is made; no movement means an open capacitor; no resistance means capacitor is shorted	Replace capacitor or take motor to service station
9. Motor shorted out	If fuse blows when pump is started (and external wiring is OK) motor is shorted	Replace motor

Motor Overheats and Overload Trips Out

Cause of Trouble	How to Check	How to Correct
1. Incorrect line voltage	Use voltmeter to check at pressure switch or terminals nearest pump	If voltage under recommended minimum, check size of wiring from main switch on property; if OK, contact power company
2. Motor wired incorrectly	Check motor wiring diagram	Reconnect for proper voltage as per wiring diagram
3. Inadequate ventilation	Check air temperature where pump is located; if over 100°F., overload may be tripping on external heat	Provide adequate ventilation or move pump
4. Prolonged low pressure delivery	Continuous operation at very low pressure places heavy overload on pump; this can cause overload protection to trip	Install glove valve on discharge line and throttle to increase pressure

Table 4. Trouble Shooting Guide-Jet Pumps continued

Pump Starts and Stops Too Often

Cause of Trouble	How to Check	How to Correct
1. Leak in pressure tank	Apply soapy water to entire surface above water line. If bubbles appear, air is leaking from tank	Repair leaks or replace tank
2. Defective air volume control	This will lead to a waterlogged tank; make sure control is operating properly; if not, remove and examine for plugging	Clean or replace defective control
3. Faulty pressure switch	Check switch setting; examine switch contacts for dirt or excessive wear	Adjust switch settings; clean contacts with emory cloth if dirty
4. Leak on discharge side of system	Make sure all fixtures in plumbing system are shut off; then check all units (especially ballcocks) for leaks; listen for noise of water running	Repair leaks as necessary
5. Leak on suction side of system	On shallow well units, install pressure gauge on suction side On deep well systems, attach a pressure gauge to the pump; close the discharge fine valve; then, using a bicycle pump or air compressor, apply about 30 psi pressure to the system; if the system will not hold this pressure when the compressor is shut off, there is a leak on the suction side	Make sure above ground connections are tight; then repeat test; if necessary, pull piping and repair leak
6. Leak in foot valve	Pull piping and examine foot valve	Repair or replace defective valve

Pump Will Not Shut Off

Cause of Trouble	How to Check	How to Correct
1. Defective pressure switch	Arcing may have caused pressure switch points to "weld" in closed position; examine points and other parts of switch for defects	Clean points or replace switch
2. Water level in well too low	Well production may be too low for pump capacity; restrict flow of pump output, wait for well to recover, and start pump	If partial restriction corrects trouble, leave valve or cock at restricted setting; otherwise, lower pump in well if depth is sufficient; do not lower if sand clogging might occur
3. Leak in drop line	Raise pipe and examine for leaks	Replace damaged section of drop pipe
4. Pump parts worn	The presence of abrasives in the water may result in excessive wear on the impeller, casing, and other close-clearance parts; before pulling pump, reduce setting on pressure switch to see if pump shuts off. If it does, worn parts are probably at fault	Pull pump and replace worn components

Table 4. Trouble Shooting Guide-Jet Pumps continued

Pump Operates But Delivers Little or No Water		
Cause of Trouble	How to Check	How to Correct
1. Low line voltage	Use voltmeter to check at pressure switch or terminals nearest pump	If voltage under recommended minimum, check size of wiring from main switch on property; if OK, contact power company
2. System incompletely primed	When no water is delivered, check prime of pump and well piping	Reprime if necessary
3. Air lock in suction line	Check horizontal piping between well and pump; if it does not pitch upward from well to pump, an air lock may form	Rearrange piping to eliminate air lock
4. Undersized piping	If system delivery is low, the discharge piping and/or plumbing lines may be undersized; refigure friction loss	Replace undersized piping or install pump with higher capacity
5. Leak in air volume control or tubing	Disconnect air volume control tubing at pump and plug hole; if capacity increases, a leak exists in the tubing of control	Tighten all fittings and replace control if necessary
6. Pressure regulating valve stuck or incorrectly set (deep well only)	Check valve setting; inspect valve for defects	Reset, clean, or replace valve as needed
7. Leak on suction side of system	On shallow well units, install pressure gauge on suction side; on deep well systems, attach a pressure gauge to the pump; close the discharge line valve; then, using a bicycle pump or air compressor, apply about 30 psi pressure to the system; if the system will not hold this pressure when the compressor is shut off, there is a leak on the suction side	Make sure above ground connections are tight; then repeat test; if necessary, pull piping and repair leak
8. Low well level	Check well depth against pump performance table to make sure pump and ejector are properly sized	If undersized, replace pump or ejector
9. Wrong pump-ejector combination	Check pump and ejector models against manufacturer's performance tables	Replace ejector if wrong model is being used
10. Low well capacity	Shut off pump and allow well to recover; restart pump and note whether delivery drops after continuous operation	If well is "weak," lower ejector (deep well pumps), use a tail pipe (deep well pumps), or switch from shallow well to deep well equipment
11. Plugged ejector	Remove ejector and inspect	Clean and reinstall if dirty
12. Defective or plugged foot valve and/or strainer	Pull foot valve and inspect; partial clogging will reduce delivery; complete clogging will result in no water flow; a defective foot valve may cause pump to lose prime, resulting in no delivery	Clean, repair, or replace as needed
13. Worn or defective pump parts or plugged impeller	Low delivery may result from wear or impeller or other pump parts; disassemble and inspect	Replace worn parts or entire pump; clean parts if required

Table 5. Trouble Shooting Guide-Submersible Pumps

Fuses Blow or Circuit Breaker Trips When Motor is Started

Cause of Trouble	How to Check	How to Correct
1. Incorrect line voltage	Check the line voltage terminals in the control box (or connection box in the case of the 2-wire models) with a voltmeter, make sure that the voltage is within the minimum-maximum range prescribed by the manufacturer	If the voltage is incorrect, contact the power company to have it corrected
2. Defective control box: a. Defective wiring	Check out all motor and power-line wiring in the control box, following the wiring diagram found inside the box; see that all connections are tight and that no short circuits exists because of worn insulation or crossed wires	Rewire any incorrect circuits; tighten loose connections; replace worn wires
b. Incorrect components	Check all control box components to see that they are the type and size specified for the pump in the manufacturers' literature; in previous service work, the wrong components may have been installed	Replace any incorrect component with the size and type recommended by the manufacturer
c. Defective starting capacitor (skip for 2-wire models)	Using an ohmmeter, determine the resistance across the starting capacitor; when contact is made, the ohmmeter needle should jump at once, then move up more slowly; no movement indicates an open capacitor (or defective relay points); no resistance means that the capacitor is shorted	Replace defective starting capacitor
d. Defective relay (skip for 2-wire models)	Using an ohmmeter, check the relay coil; its resistance should be as shown in the manufacturers' literature; recheck ohmmeter reading across starting capacitor with a good capacitor, no movement of the needle indicates defective relay points	If coil resistance is incorrect or points defective, replace relay
3. Defective pressure switch	Check the voltage across the pressure switch points; if less than the line voltage determined in "1" above, the switch points are causing low voltage by making imperfect contact	Clean points with a mild abrasive cloth or replace pressure switch
4. Pump in crooked well	If wedged into a crooked well, the motor and pump may become misaligned, resulting in a locked rotor	If the pump does not rotate freely, it must be pulled and the well straightened
5. Defective motor winding or cable: a. Shorted or open motor winding	Check the resistance of the motor winding by using an ohmmeter on the proper terminals in the control box (see manufacturers' wiring diagram); the resistance should match the ohms specified in the manufacturers' data sheet; if too low, the motor winding may be shorted; if the ohmmeter needle doesn't move, indicating high or infinite resistance, there is an open circuit in the motor winding	If the motor winding is defective--shorted or open--the pump must be pulled and the motor repaired
b. Grounded cable or wiring	Ground one lead of the ohmmeter onto the drop pipe or shell casing, then touch the other lead to each motor wire terminal; if the ohmmeter needle moves appreciably when this is done, there is a ground in either the cable or the motor winding	Pull the pump and inspect the cable for damage; replace damaged cable; if cable checks OK, the motor winding is grounded
6. Pump sand locked	Make pump run backwards by interchanging main and start winding (black and red) motor leads at control box	Pull pump, disassemble and clean; before replacing, make sure that sand had settled in well; if well is chronically sandy, a submersible should not be used

Table 5. Trouble Shooting Guide-Submersible Pumps continued

Pump Operates But Delivers Little or No Water		
Cause of Trouble	How to Check	How to Correct
1. Pump may be air locked	Stop and start pump several times, waiting about one minute between cycles; if pump then resumes normal delivery, air lock was the trouble	If this test fails to correct the trouble, proceed as below
2. Water level in well too low	Well production may be too low for pump capacity; restrict flow of pump output, wait for well to recover, and start pump	If partial restriction corrects trouble, leave valve or cock at restricted setting; otherwise, lower pump in well if depth is sufficient; do not lower if sand clogging might occur
3. Discharge line check valve installed backward	Examine check valve on discharge line to make sure that arrow indicating direction of flow points in right direction	Reverse valve is necessary
4. Leak in drop pipe	Raise pipe and examine for leaks	Replace damaged section of drop pipe
5. Pump check valve jammed by drop pipe	When pump is pulled after completing "4" above, examine connection of drop pipe to pump outlet; if threaded section of drop pipe has been screwed in too far, it may be jamming the pump's check valve in the closed position	Unscrew drop pipe and cut off portion of threads
6. Pump intake screen blocked	The intake screen on the pump may be blocked by sand or mud; examine	Clean screen, and when reinstalling pump, make sure that it is located several feet above the well bottom-preferably 10 feet or more
7. Pump parts worn	The presence of abrasives in the water may result in excessive wear on the impeller, casing, and other close-clearance parts; before pulling pump, reduce setting on pressure switch to see if pump shuts off. If it does, worn parts are probably at fault.	Pull pump and replace worn components
8. Motor shaft loose	Coupling between motor and pump shaft may have worked loose; inspect for this after pulling pump and looking for worn components, as in "7" above	Tighten all connentions and setscrews
Pump Starts Too Frequently		
Cause of Trouble	How to Check	How to Correct
1. Pressure switch defective or out of adjustment	Check setting on pressure switch and examine for defects	Reduce pressure setting or replace switch
2. Leak in pressure tank above water level	Apply soap solution to entire surface of tank and look for bubbles indicating air escaping	Repair or replace tank
3. Leak in plumbing system	Examine service line to house and distribution branches for leaks	Repair leaks
4. Discharge line check valve leaking	Remove and examine	Replace if defective
5. Air volume control plugged	Remove and inspect air volume control	Clean or replace
6. Snifter valve plugged	Remove and inspect snifter valve	Clean or replace

Table 5. Trouble Shooting Guide-Submersible Pumps continued

Motor Does Not Start, But Fuses Do Not Blow

Cause of Trouble	How to Check	How to Correct
1. Overload protection out	Check fuses or circuit breaker to see that they are operable	If fuses are blown, replace; if breaker is tripped, reset
2. No power	Check power supply to control box (or overload protection box) by placing a voltmeter across incoming power lines; voltage should approximate nominal line voltage	If no power is reaching box, contact power company for service
3. Defective control box	Examine wiring in control box to make sure all contacts are tight; with a voltmeter, check voltage at motor wire terminals; if no voltage is shown at terminals, wiring is defective in control box	Correct faulty wiring or tighten loose contacts
4. Defective pressure switch	With a voltmeter, check voltage across pressure switch while the switch is closed; if the voltage drip is equal to the line voltage, the switch is not making contact	Clean points or replace switch

Fuses Blow When Motor is Running

Cause of Trouble	How to Check	How to Correct
1. Incorrect voltage	Check line voltage terminals in the control box (or connection box in the case of 2-wire models) with a voltmeter; make sure that the voltage is within the minimum-maximum range prescribed by the manufacturer	If voltage is incorrect, contact power company for service
2. Overheated overload protection box	If sunlight or other source of heat has made box too hot, circuit breakers may trip or fuses blow; if box is hot to the touch, this may be the problem	Ventilate or shade box, or remove from source of heat
3. Defective control box components (skip this for 2-wire models)	Using an ohmmeter, determine the resistance across the running capacitor; when contact is made, the ohmmeter needle should jump at once, then move up more slowly; no movement indicates an open capacitor (or defective relay points); no resistance means that the capacitor is shorted Using an ohmmeter, check the relay coil; its resistance should be as shown in the manufacturer's literature. Recheck ohmmeter reading across running capacitor; with a good capacitor, no movement of the needle indicates relay points	Replace defective components
4. Defective motor winding or cable	Check the resistance of the motor winding by using an ohmmeter on the proper terminals in the control box (see manufacturer's wiring diagram); the resistance should match the ohms specified in the manufacturer's data sheet; if too low, the motor winding may be shorted; if the ohmmeter needle doesn't move, indicating high or infinite resistance, there is an open circuit in the motor winding Ground one lead if the ohmmeter onto the drop pipe or shell casing, then touch the other lead to each motor wire terminal; if the ohmmeter needle moves appreciably when this is done, there is a ground in either the cable or the motor winding	If neither cable or winding is defective-shorted, grounded, or open-pump must be pulled and serviced
5. Pump becomes sandlocked	If the fuses blow while the pump is operating, sand or grit may have become wedged in the impeller, causing the rotor to lock; to check this, pull the pump	Pull pump, disassemble, and clean; before replacing, make sure that sand has settled in well; if well is chronically sandy, a submersible should not be used

Table 5. Trouble Shooting Guide-Submersible Pumps continued

Pump Will Not Shut Off		
Cause of Trouble	How to Check	How to Correct
1. Wrong pressure switch setting or "drift"	Lower switch; if pump shuts off, this was the trouble	Adjust switch to proper setting
2. Defective pressure switch	Arcing may have caused switch contacts to "weld" together in closed position; examine points and other parts of switch for defects	Replace switch if defective
3. Tubing to pressure switch plugged	Remove tubing and blow through it	Clean or replace if plugged
4. Loss of prime	When no water is delivered, check prime of pump and well piping	Reprime if necessary
5. Low well level	Check well depth against pump performance table to make sure pump and ejector are properly sized	If undersized, replace pump or ejector
6. Plugged ejector	Remove ejector and inspect	Clean and reinstall if dirty

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.

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