

WATER, SANITATION, AND HYGIENE

SECTOR CASE STATEMENT

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Introduction

Water is the basis of all life. But for millions of children, the water they drink can also be a source of persistent illness, leading to an early grave. A child dies of diarrheal disease every 30 seconds¹—and for every child who dies of diarrheal disease, three more children die of other diseases passed along by unwashed hands, or made more deadly by chronic malnutrition resulting from constant bouts of diarrheal disease and intestinal parasites.^{2,3} Thus, every 7 seconds, a child in the developing world dies of WASH-related disease or WASH-related malnutrition.

According to the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC), 80 percent of all childhood diseases are WASH-related.^{4,5} While adults also suffer from WASH-related diseases, 90 percent of those who succumb to them are children under the age of 5.⁶ Even more alarming, 70 percent of these don't survive the first year of life, and 40 percent don't make it past the first month.¹ Before we can help these children to thrive, we must help them simply to survive. Providing a child with access to safe water, sanitation, and hygiene is one of the most effective ways to ensure his or her survival.⁷

World Vision is ready for such a challenge. We are well-established in the WASH sector, with more than 25 years of experience, and we have developed effective partnerships with government agencies, private charitable foundations, nonprofit organizations, cutting-edge research institutions, major corporations, and the communities themselves. We have staff with the technical expertise to investigate and implement innovations that can dramatically increase access to clean water, sanitation, and hygiene education. And we have the determination to bring this vision to reality.

Why WASH?

It is hard to think of a more potent reason to redouble our efforts than the harsh reality that nearly 8 million children this year will not live to see their fifth birthday.¹ While the number of annual child deaths has dropped by half over the past 30 years due to efforts by governments and aid agencies,⁸ far more remains to be done, especially in the WASH sector.⁹

Research reveals that 80 percent of childhood disease is related directly or indirectly to unsafe drinking water, inadequate hygiene, and open defecation.^{4,5}

- It is a well-known fact that almost 90 percent of all child deaths from diarrheal diseases—or about 1.1 million per year—are related to unsafe water and inadequate sanitation. Diarrheal disease is responsible for 15 percent of deaths worldwide among children younger than 5.^{6,7}
- What is less well-known is that more than one-third, and in some low-income contexts as much as two thirds, of all neonatal mortality results from unhygienic birthing and post-partum care.¹⁰
- Furthermore, about half of all pneumonia deaths—750,000 children per year—also result from poor hygiene.¹¹
- Perhaps most surprising of all is the fact that more than half of the chronic malnutrition among children in the developing world is due to repeated infection by diarrheal diseases and intestinal parasites, leading to another million child deaths from otherwise survivable diseases.¹²

All told, some 5 million children die every year due to WASH-related disease, malnutrition, and their consequences, and at least 4 million are preventable through WASH interventions (see table below).

The case for WASH

Causes of Death (children younger than 5)	2010 Child Deaths	Percent of Total	Estimated WASH Related	Estimated WASH Preventable
Neonatal	2.74M	36	50%? (1.37M?)	33%? (0.9M?)
Nutritional (co-factor)	[2.66M]	[35]	54%	39%
Diarrheal	1.14M	15	88% (1.0M)	65% (0.74M)
Pneumonial	1.37M	18	55% (0.75M)	40% (0.55M)
Malarial	0.61M	8	57% (0.35M)	23% (0.14M)
Other infections	1.52M	20	± 80% (1.46M)	± 70% (1.06M)
Accidents	0.23M	3	n/a	n/a
TOTAL	7.61M	100	± 65% (±4.93M)	± 55% (±4.18M)

More than half of these deaths (2.2M) are preventable with basic WASH interventions such as hand pumps, latrines, and handwashing with soap. To address the remaining 2.0M deaths requires more advanced WASH interventions such as tap water and flush toilets in homes, which cost at least three times as much as basic WASH measures.

The Case for a Nearby Safe Water Supply

Nearly 900 million people in today's world—one person in eight—collect water from a contaminated source, which often is quite some distance from the home and may consume 4 to 6 hours every day.⁷ Typically, the back-breaking burden for collecting this water falls upon women and older girls.¹³ Our standard for safe water supply echoes the WHO standard of 20 liters (5 gallons) per person per day within a 30-minute roundtrip walk from the home. Increased access to safe water close to home means more time and energy for women to engage in economic activities, and for girls to attend school.¹⁴ The majority of productive uses of water close to its source are managed by women whose time has been liberated from the daily task of fetching water from a distant source. WASH interventions not only have a profound effect on the health, education, and livelihoods of women and girls, but women and girls in turn have a profound effect on the functionality and sustainability of our WASH improvements. (See Appendix A for more about the crucial relationship between women and water.)

The Case for Sanitation

More than 2.6 billion people around the world—one in three—lack basic sanitation facilities.⁷ This results in 4 billion cases of diarrhea each year and 400 million children chronically infected by intestinal parasites.¹⁵ Persistent diarrhea and parasite infections result in chronic malnutrition, a compromised immune system, and impaired brain development. Whipworm infection accounts for half of all school absenteeism in the developing world. In fact, one study showed that 40 percent of worm infections resulted from unsanitary conditions at school.¹⁶ A study by UNICEF concluded that sanitation interventions were among the most cost-effective of all interventions in lowering the rate of death among children younger than 5 in the developing world, at a cost of about \$11 per year of life saved (the technical term is DALY, or Disability Adjusted Life Years).¹⁴ This is compelling enough, but on top of this is the fact that for every dollar invested in sanitation, a community obtains \$9 in economic returns.⁷

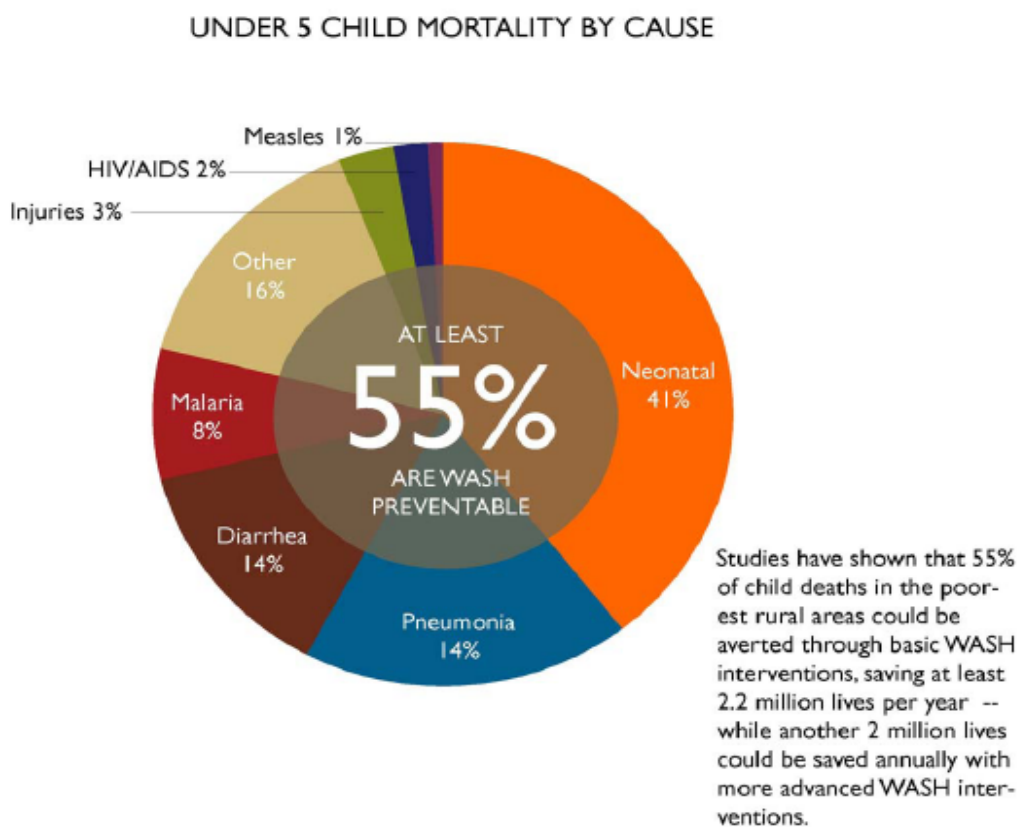
The Case for Hygiene Promotion

Of all the interventions available to us, hygiene promotion is the most cost-effective. Studies show that the cost per DALY saved is just over \$3. This compares to a cost per DALY of \$94 for a well equipped with a hand pump.¹⁷ In Nepal, a study published by the AMA showed that teaching birth attendants and new mothers to wash their hands with soap and clean water before touching babies reduced neonatal deaths by 44 percent.¹⁰ Another study showed that getting older children to wash their hands properly before eating, before preparing food, and after using the toilet reduced diarrheal disease among younger children in the home by up to 47 percent.¹⁸ Research further reveals that 70 percent of diarrheal cases are due to contaminated weaning food, the consequence mainly of preparing food with unwashed hands.¹⁹ Handwashing with soap could prevent half of diarrheal deaths, a third or more of neonatal deaths, and a quarter of pneumonial deaths—at least 2 million deaths per year of children younger than 5—plus another 200,000 annual deaths from measles, flu, and other communicable diseases.^{10,20} Face washing with clean water, meanwhile, could prevent at least a third of active trachoma cases, thus preventing 1.9 million cases of blindness.²¹ Beyond the obvious health benefits, studies show that access to safe water near homes and schools increases school attendance. For example, a study in China showed that school absenteeism was reduced by 54 percent by providing soap and water at school.²²

The Case for Integrating Water, Sanitation and Hygiene

A number of rigorous studies over the past two decades have confirmed that a large proportion of child deaths are preventable through basic WASH interventions. However, these studies also make it clear that such interventions must be implemented in an integrated way, not as stand-alone projects, or the impact will be muted. For example, the net impact on diarrheal deaths among children younger than 5 of providing access to safe water is only 3 percent to 5 percent if unaccompanied by other interventions,

whereas providing access to effective sanitation reduces such deaths by 5 percent to 10 percent (latrines) up to 20 percent (flush toilets).²³ However, the impact of safe water is multiplied many times over by combining it with improved sanitation in the same location—the median reduction in all-cause child deaths when the two are joined is 55 percent.² This is because access to clean water is a prerequisite to maximize the health impacts of sanitation, and effective sanitation is a prerequisite to maximize the health impacts of safe water. This effect is known as the Mills-Reincke Multiplier, named for two early researchers who observed this phenomenon when safe water and sanitation were introduced to the city of Hamburg, Germany, in 1893.²³



Sources: Levels & Trends in Child Mortality Report 2010, UNICEF; WASH: WHO Key family practices on child survival, Hill et al. (2001)
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The Case for Integrating WASH with Other Primary Sectors

The Lancet Journal has estimated that a small number of low-cost, proven health interventions, including WASH, can reduce child deaths by at least 63 percent if intelligently integrated.²⁴ World Vision’s Global Health-Nutrition Team has estimated that by combining our 7-11 health-nutrition interventions synergistically with basic WASH interventions, we can expect a reduction in overall child deaths of as much as 70 percent in the target areas.²⁵ The 7-11 strategy is funded by child sponsorship dollars and is at work in virtually all of the areas where WASH interventions are planned or under way. (See Appendix B for a detailed look at the 7-11 interventions.)

Why now?

We must act now because, especially for children, the window of opportunity is quite narrow. Most of the 8 million annual deaths of children younger than 5 occur within two years of birth. In fact, more than 40 percent of these deaths occur within four weeks of birth.¹ For many of these children, a delay in program expansion means more than continued hardship and illness—it means death.

Over the past 25 years, some 11 million people have benefited from our WASH interventions. But what we've already done isn't nearly enough. For example, in the high-need areas we've selected in Africa, 53 percent of children don't have access to safe water, 74 percent lack improved sanitation, and only 22 percent have received any kind of hygiene training.⁹ We cannot be satisfied with the current situation; nor can we afford to lose the opportunity to safeguard and transform the lives of vulnerable children in those places where we can make a difference.

It is reassuring that the worldwide aid community is taking the same stance. In September 2000, building upon a decade of major United Nations conferences and summits, world leaders gathered in New York and adopted the United Nations Millennium Declaration.²⁶ They committed themselves to a new global partnership to reduce extreme poverty, and established a series of time-bound targets—with a deadline of 2015—that have become known as the Millennium Development Goals. The eight goals form a blueprint supported by all of the world's nations and leading development institutions. They have galvanized unprecedented efforts to meet the needs of the world's poorest people.

The Millennium Development Goal (MDG) for WASH is to reduce by half the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015. In March 2010, UNICEF and the WHO indicated that, at the current pace, we are on target to reach the safe water access goal. That's the good news. The bad news is that we likely will fall a half-billion people short of the sanitation goal.⁹ Yet, as we have seen, sanitation efforts are indispensable if we are to obtain the full impact of safe water. We must do our part to make the linkages inseparable.

Why rural Africa?

We have chosen to begin in Africa because this is where the need is greatest. Nearly half of all deaths among children younger than 5 (48.8 percent) occur in sub-Saharan Africa, despite the fact this area accounts for only 11 percent of the global population.¹ This is the poorest region of the world, and not surprisingly it also is the area where access to safe water and effective sanitation is the lowest. Coverage averages 58 percent for safe water and 31 percent for sanitation. Other disparities also are apparent: More than 80 percent of those lacking access to safe water and sanitation live in rural areas, especially in the rural areas of sub-Saharan Africa and South Asia.²⁷ Thus, World Vision has chosen to begin in the rural zones of Africa, focusing on our project areas where coverage is the lowest. South Asia takes second priority, followed by Central America and the Caribbean.

Why World Vision?

World Vision has a long history of providing clean water and sanitation for millions of children and their families. In the 1960s and 1970s, World Vision's water projects were primarily small undertakings

in individual communities. However, the scale of World Vision's water development work increased substantially when sub-Saharan Africa suffered massive droughts in the early 1980s. By 1985, World Vision had initiated major water development activities—mostly drilling boreholes—in Ethiopia, Ghana, Kenya, Malawi, and Senegal. In 1986, the United States Agency for International Development (USAID) awarded World Vision a five-year grant totaling \$6 million for our Africa Water Program. When that grant came to an end, funding from the Conrad N. Hilton Foundation and private individuals such as the Dornsife family picked up the slack and kept the program going and growing. Over the past 25 years, World Vision has provided clean water to some 11 million people, primarily in Africa. From drilling wells to rehabilitating existing water systems, from building latrines to promoting good hygiene, our aim is to save children from some of the most dangerous killers on earth: contaminated water, open defecation, and unwashed hands and dishes.

We don't just implement water projects; we routinely evaluate them to learn how we can better serve people. We also have established Learning Centers in each of the three regions of Africa specifically to discover and disseminate best and promising practices, and we have created an Innovation Fund that will enable us to test and pilot cutting-edge interventions. Our goal is to continually increase both the impact and the sustainability of our interventions while lowering the costs.

As an example of the sustainability for which we strive, a third-party survey of wells constructed by World Vision in central Ghana—some of which were installed as far back as 1990—showed that 87 percent of the wells were still providing an adequate quantity of safe water. (Please see Appendix C for a borehole sustainability article by Peter Harvey.) This good report card only caused our Ghana WASH team to want to do even better. Subsequent third-party evaluations of our work in the same area of Ghana showed that our borehole functionality had increased from 87 percent in 2003 to 95 percent in 2008, and 100 percent in 2011. This compares with a typical sustainability record of 20 to 30 percent still functioning after five years for most nongovernmental organizations. Our excellent record is a result of empowering and equipping community members to care for their water sources.

Community empowerment and capacity building is only possible because World Vision's WASH projects are implemented within World Vision Area Development Programs (ADPs). This approach focuses on a cluster of communities in geographic proximity. The ADP concept typically integrates the sectors of WASH, primary healthcare, food security, education, and economic development over a period of 12 to 18 years. Our community-based ADP approach carries with it many distinct advantages over isolated, stand-alone water projects. (See Appendix D for a summary of ADP advantages.)

Conclusion

There are plenty of causes demanding our time, talent, and treasure. But if children are our most precious resource, and if “doing unto others” means helping to save the lives of their children and safeguard their future, WASH is one of the most strategic interventions we can support. WASH saves lives and paves the way to meeting nearly every other need in a community, be it livelihood transformation, social transformation, or spiritual transformation. In short, WASH is not only “the first and best medicine,” it also is the first step toward “life in all its fullness.”

Sources

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Appendix A

The case for women

From a young age, women and girls suffer from society's views on gender, impacting their rights for education and safety. In many nations, daughters are expected to drop out of school when families need help at home. If parents cannot afford an education for all of their children, boys are favored over girls. As they grow older, females endure a different form of gender inequality and discrimination. Often unaware of their rights, victims hide their physical and emotional scars, frequently believing the violence and discrimination are deserved.

Impact of WASH on women

Women collect water in nearly two-thirds of households in the developing world. In the 12 percent of households where children collect water, girls are twice as likely as boys to be responsible for that task.¹ By reducing the distance between water points and strategically locating them near schools, a generation of women's untapped potential becomes unleashed, empowering them to break their family's legacy of poverty.

Increased access to safe water means more opportunities, especially for women, to engage in economic activities. Women who receive vocational and business training are better able to meet their basic needs and the needs of their families. As women use this increased income to benefit their families and communities, a generation can begin to rise out of poverty.

Unsanitary latrines or lack of access to gender-separated latrines also pose threats to girls at school. Studies show that girls miss school or drop out entirely during their menstrual cycle because of inadequate facilities or because of the fear of being sexually assaulted. In addition, unsanitary facilities are a breeding ground for infection and can lead to the contraction of diarrhea, guinea-worm, pneumonia, or other water-related diseases. World Vision is responding to this issue by building gender-separated latrines and ensuring gender equality in school WASH & Health Clubs, all helping to create a safe environment for girls to go to school confidently.

Impact of women on WASH

Women are severely under-represented in managerial occupations in all developing regions, accounting for more than 30 percent of such positions in just two out of nine regions.² Studies show that when women have ownership and control over resources, they invest more of their income in the health, education, and well-being of their families. That is why World Vision is requiring that at least two females from each community sit on WASH committees. WASH committees are essential to ensure the sustainability of interventions in the community and are responsible for the continued education of children and families in hygiene and sanitation—an invaluable sphere of influence for women.

^{1,2} United Nations, 2010. *Millennium Development Goals: Gender Equality and Women's Empowerment*.

World Vision is empowering women and girls with the knowledge, skills, and resources to gain independence, confidence, and recognition for their worth in their households and communities. Girls who attend school will be more likely to pursue higher education and a career. When they become mothers, they will instill in their children the importance of education. Children of educated mothers have a better chance for survival—the mortality rate of children from mothers without education is more than twice that of women with secondary education or higher.³ An educated mother can start a domino effect for education among ensuing generations—a better hope for securing safe water, adequate sanitation, and good hygiene education.

³ Under-five mortality rate of children from mothers without education was 126 per 1,000 births, from mothers with primary education it was 97 per 1,000 births, and mothers with secondary education or higher—57 per 1,000 births. (United Nations, 2010. *Millennium Development Goals: Gender Equality and Women's Empowerment*.)

Appendix B

7-11 Programmatic Interventions to Improve the Health and Nutrition Of Pregnant Women and Children 0-24 Months

World Vision’s Health and Nutrition Goal

We are committed to improving the health and nutrition of women and children in the areas in which we work, contributing to the global reduction of under-5 and maternal mortality. (Please see The Case for Women, Appendix A.)

Child Well-Being Outcomes

World Vision is focusing on three essential outcomes to achieve this goal:

1. Mothers and children are well nourished.⁴
2. Mothers and children are protected from infection and disease.⁵
3. Mothers and children access essential health services.⁶

The health goal is dependent on the success of the full breadth of World Vision’s child well-being outcomes, applied in an intergenerational cycle. This will only be achieved through effective integration of health outcomes with multiple sectors and ministries.

		Target Groups	
		Pregnant Women	Children: 0-24 Months
Core interventions	1.	Consumption of additional food	1. Exclusive breast-feeding for 6 months, with continued breast-feeding until 24 months
	2.	Iron supplementation	2. Early warning
	3.	Tetanus toxoid immunization	3. Complementary feeding (6-24 months)
	4.	Deworming*	4. Iron supplementation (e.g., syrup, fortified foods)
	5.	Use of long-lasting, insecticide-treated nets/Artemisin-based combination therapy*	5. Vitamin A capsule supplementation
	6.	Intermittent preventive malaria treatment*	6. Deworming*
	7.	Voluntary counseling and testing for HIV infection*	7. Use of long-lasting, insecticide-treated nets*
			8. Oral rehydration therapy
			9. Care seeking for acute respiratory infection
			10. Birth spacing
			11. Full immunization

* as appropriate in context

Our Strategy

1. Scale up of an organization-wide, evidence-based, cost-effective and internationally recommended set of preventive practices. Our “7-11” minimum set of interventions includes:
2. Our delivery models for health and nutrition interventions commence with core and contextualized interventions (Phase I), and then build on integrated activities over time to address the wider local causes of illness and malnutrition (Phase II).
3. Our delivery models are three-pronged:
 1. They focus on primary health and nutrition education and behavior change at the household level, empowering caregivers and children to keep themselves healthy.
 2. They build the capacity of community groups to address and monitor local causes of illness, death, and malnutrition, advocate for quality health service delivery, and monitor home-based care services.
 3. They build the capacity of government and other partners to deliver quality health and nutrition services to the community level.

⁴ Measured by rates of stunting and anemia.

⁵ Measured by rates of malaria/illnesses, care seeking for treatment or diarrhea and ARI, and immunization rates.

⁶ Measured by rate of skilled attendance at birth and antenatal care coverage.

World Vision's 7-11 Health-Nutrition Strategy

7 Interventions for New Mothers

Intervention	Health and Nutrition	WASH	Agriculture/ Food Security	Education and Literacy	Economic Development
1. Adequate Diet	Increased amount, quality, and frequency of food during pregnancy and lactation	Water for small-scale irrigation of vegetable gardens, promotion of vegetables rich in vitamin A, iron, and zinc	Technical support to farmers for production and storage of nutrient-dense foods	Reinforcement of nutrition messages in schools, especially for older girls	Market research around nutritious products essential during pregnancy and lactation for farmers and entrepreneurs
2. Iron/Folate Supplements	Access to iron/folate is facilitated during pregnancy. Promote locally available iron/folate-rich foods, such as animal foods, and foods rich in vitamins A and C	Water for small-scale irrigation of vegetable gardens, promotion of vegetables rich in vitamin A, iron, and zinc	Technical support to farmers for production and storage of nutrient-dense foods	Reinforcement of nutrition messages in schools, especially for older girls	Market research around essential micronutrients for use by farmers and entrepreneurs
3. Tetanus Toxoid Immunization	Two doses of TT during pregnancy as per national guidelines			Reinforcement of immunization messages in schools	
4. Malaria Prevention, Treatment Access, and IPTp	Intensified focus on LLIN distribution, usage, and hanging. intermittent preventive treatment during pregnancy according to NG CT/ACT access for mothers with malaria	Better management of community water resources to reduce malaria. Promotion of vegetables rich in iron (anemia due to malaria)	Better management of dams and irrigation projects to reduce contribution to malaria.	Reinforcement of malaria prevention and treatment messages in schools	Market research and loan capital around malaria prevention products for use by entrepreneurs (e.g. insecticidal paints or indoor residual spraying (IRS) products)
5. Birth Preparedness and Birth Spacing	Birthing and emergency plans in place; understanding and recognition of complications surrounding pregnancy, delivery, and post-partum care; use of proven methods to limit or space subsequent pregnancies based on informed decisions limiting pregnancy to the healthiest years: 18 to 35 years old			Reinforcement of reproductive health messages in schools, especially to older girls	
6. De-worming	Availability and use of de-worming tablets (based on national policy); provision of de-worming tablets to the whole family, specifically pregnant women, according to national guidelines	Promotion of, and technical support for, household latrine or toilet construction, and promotion of Community-Led Total Sanitation Access to safe drinking water through household water treatment with chlorine-peroxide	Management of water reservoirs and irrigation systems	Reinforcement of sanitation and handwashing messages in schools	Loan capital and market research in support of community water treatment devices, household latrine/toilet construction, and/or local shoe production

		solution			
7. Access to Maternal Health Services	Registration and delivery at ANC; primary HIV prevention education among men and women, condom usage; symptomatic mothers screened for TB, SM+ register for DOTS; pre- and post-test counseling for HIV+ mothers; mother and infant receive NVP post-partum counseling to include infant feeding (EBF for 6 months)			Reinforcement of reproductive health messages in schools, especially to older girls	

II Interventions for Young Children (birth-5 years old, with focus on birth-2)

Intervention	Health and Nutrition	WASH	Agriculture/ Food Security	Education and Literacy	Economic Development
1. Appropriate Breast-feeding	Promotion of breastfeeding within first hour of life, feeding infant colostrums; exclusive breastfeeding for six months with no additional food or use of bottles, and breastfeeding with supplementary food between 6 and 24 months	Promotion to mothers of good handwashing and hygiene prior to breastfeeding		Reinforcement of relevant health and nutrition messages in schools, especially to older girls	
2. Essential Newborn Care	Essential care during the first few hours of life; skin-to-skin with the mother for warmth; wrapping infant with the mother; clean eye care and cord care; counseling on breastfeeding in the context of HIV	Availability of soap and clean water for washing of birth attendant, mother, and newborn, and of cleaning products for sterilizing utensils and delivery room		Reinforcement of relevant health and nutrition messages in schools, especially to older girls	Loan capital for purchase of birthing equipment and utensils by TBAs
3. Handwashing	Both hands rubbed with soap, ash, salt, or lime/lemon and rinse with running water: before cooking, before eating, before handling the baby, and after using the toilet or latrine	Reinforcement of handwashing messages in community gatherings	Promotion and technical support to farmers to produce raw ingredients needed for local soap production or nutrient-dense weaning foods	Reinforcement of handwashing messages in school	Loan capital and technical support for startup of soap-making businesses
4. Appropriate Complementary	Promotion of regular attendance at growth	Availability of soap and clean water	Promotion of, and technical	Reinforcement of relevant health &	Market research and loan capital in

Feeding (6-24 months)	monitoring sessions, responsive feeding of breastfed infants; education regarding best weaning practices, including preparation of pathogen-free foods requiring no cold storage (e.g., yeast slurry or fermented breads)	needed for hygienic preparation of weaning foods and washing of feeding utensils; water treatment at household level; or improved transport and storage of safe well water or safe water treated at source	support for, production, marketing, and sale of pathogen-free and nutrient-dense weaning foods (e.g., yeast slurry, fermented breads, moringa leaf powder, acacia nut flour)	nutrition messages in schools, especially to older girls	support of businesses producing pathogen-free and nutrient-dense weaning foods for the market, especially fortified weaning foods
5. Adequate iron	Promotion of adequate intake of iron by children, especially in malaria-endemic areas and where anemia prevalence >40%; education regarding iron-rich or fortified complementary foods for children 6 to 24 months, in addition to malaria control and treatment efforts; promotion of daily iron supplementation in nonmalaria areas and where anemia <40%; promotion of diversified diet with iron-rich foods; prescribe iron tablets at 2 months for low-birth-weight infants	Water for small-scale irrigation of vegetable gardens, promotion of vegetables rich in iron	Promotion of, and technical support for, production and sale of iron-rich foods	Reinforcement of relevant health & nutrition messages in schools, especially to older girls	Market research and loan capital in support of businesses producing iron-rich weaning foods for the market
6. Vitamin A	All children 6-24 months old receive a vitamin A capsule every 6 months	Water for small-scale irrigation of vegetable gardens; promotion of vegetables rich in vitamin A	Identification and promotion of local agricultural products high in vitamin A	Reinforcement of nutrition messages in schools	
7. ORT/Zinc	Health education on hygiene, handwashing and cleanliness for diarrhea prevention; continued BF during and after diarrhea episode for < 6-month-old child; early use of ORS or appropriate HH solution during diarrhea; and continued BF and complementary feeding during and after diarrhea episode for a child 6-24 months old. Provision of 20 mg Zinc to a child for 10-14 days (10 mg for < 6	Reinforcement of health messaging on hygiene, handwashing and cleanliness for diarrhea prevention and mitigation, including zinc supplementation. Water for small-scale irrigation of vegetable gardens, promotion of produce rich in zinc Improved water supply for households Water treatment at	Promotion of, and technical support for, production and sale of foods rich in zinc (seafood, potatoes, certain kinds of nuts or tree seeds such as <i>acacias kunu</i> , <i>prosopos africana</i> , etc.) Discourage disposal of human feces in agricultural fields; promote community compost bank	Reinforcement of hygiene and health messaging for diarrhea prevention and mitigation, including the importance of zinc supplements for diarrhea IEC for safe drinking water and household water treatment, improved sanitation, and proper waste disposal	Market research and loan capital in support of businesses producing zinc-rich weaning foods for the market

	months child)	point of use Improved sanitation at household level	for pathogen-free composting		
8. Care Seeking for Fever	Training of VHW's and caregivers to take a child with fever to local health facility within 24 hours and ensure access to ACTs outside the home; community-based management (caregiver and CHW) of mild to moderate fever; continued BF and CF; child sleeps under LLIN	Safe water supply Better management of community water resources	Better management of dams and irrigations projects to reduce contribution to malaria burden	Reinforcement of health messaging in schools re malaria prevention and treatment, including care-seeking behavior	Market research and loan capital around malaria prevention products for use by entrepreneurs (e.g., insecticidal paints or HH IRS products) Community funds/loans for transporting children with fever to health facilities within 24 hours
9. Full Immunization for Age	Promotion of immunization according to NG; immunization at ANC national Immunization clinics/centers	Safe water supply at health facilities		Reinforcement of health messaging in schools for full immunization by first birthday	
10. Management of Acute Respiratory Infection (ARI)	Education regarding danger signs of pneumonia (rapid breathing, difficult breathing-chest in-drawing, nasal flare, fever); promotion of home-based management of cough, cold, and fever (NG); referral to HF for high fever with danger signs	Reinforcement of hand washing messages in community gatherings Water for small-scale irrigation of vegetable gardens, promotion of vegetables rich in vitamin A, iron, and zinc	Promotion and technical support around local biofuel or biogas production as an alternative to wood-burning or charcoal-burning cooking and home heating methods	Reinforcement of health messaging in schools regarding ARI prevention – reinforce full immunization by first birthday and household smoke reduction	Market research and loan capital for clean-burning stoves and fuels in the home for use by entrepreneurs Community funds/loans for immediate transport of children with danger signs of pneumonia to health facilities
11. Deworming	Children 12-24 months are given periodic deworming tablets according to national guidelines	Promotion of, and technical support for, household latrine or toilet construction, and promotion of Community-Led Total Sanitation Access to safe drinking water through household water treatment with chlorine at point of use	Management of water reservoirs and irrigation systems	Reinforcement of handwashing and sanitation messages in schools	Loan capital and market research in support of household latrine construction or toilet installation

PEOPLE-CENTRED APPROACHES TO WATER AND ENVIRONMENTAL SANITATION

Borehole Sustainability in Rural Africa: An analysis of routine field data

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Handpump-equipped boreholes are one of the most common water supply technologies adopted in rural Africa, but often demonstrate low levels of sustainability. In addition to operational problems with the pump, the borehole itself may cease to provide adequate quantities of safe drinking water only a short time after construction. This can have a significant negative impact on poor rural communities, particularly in the dry season when alternative water sources are scarce. A study of 302 boreholes in Ghana aimed to investigate rapid-onset borehole failure in relation to field data typically available following drilling and development. The study showed that the likelihood of borehole failure increased by a factor of six when drilling occurred during the wet season, and discovered a strong correlation between monthly precipitation and respective failure rates for boreholes drilled in each month. The potential for borehole failure also increased significantly when the initial yield was below the guideline value of 10 l/min. There was no indication, however, that a higher guideline value would be a cost-effective measure to reduce failure rates.

Introduction

Groundwater provides potable water to an estimated 1.5 billion people worldwide daily (DFID, 2001) and has proved the most reliable resource for meeting rural water demand in sub-Saharan Africa (MacDonald & Davies, 2002). Boreholes equipped with handpumps are a common technology adopted by poor rural communities, and there are currently approximately 250,000 handpumps in Africa (HTN, 2003). In 1994 it was estimated that 40-50% of handpumps in sub-Saharan Africa were not working (Diwi Consult & BIDR, 1994). This is backed up by more recent data from Uganda (DWD, 2002) and South Africa (Hazelton, 2000), which indicate similar operational failure rates. An evaluation in Mali in 1997 found 90% of pumps inoperable just one year after installation (World Bank, 1997). The primary reason for these high failure rates, and hence low sustainability, is insufficient attention to operation and maintenance of the pump (Harvey & Reed, 2004). This borehole itself, however, is sometimes the source of the problem. This study aims to investigate cases in which it is the borehole, rather than the pump, that has failed.

The term borehole failure as used here refers to a situation in which a borehole which is deemed 'successful' at the time of drilling subsequently fails to deliver a sufficient yield of safe water throughout the year. This does not necessarily refer to the structural failure of the borehole itself, but may occur due to a number of reasons, including depletion of groundwater levels in weathered aquifers and insufficient recharge of fractured aquifers resulting in dry boreholes. Failure may also occur as a result of: a reduction in yield; plugging of the formation around the well screen by fine particles; sand pumping due to siltation, incrustation or corrosion of casing and screens; and structural collapse

of casing and screens, often as a result of corrosion due to low-pH (acidic) waters (Driscoll, 1995). Over abstraction of water from the aquifer, and the ingress of pollutants may also result in borehole failure. Boreholes which are ephemeral in nature due to seasonal fluctuations in yield and water level, are also classified as failures, since although water was available directly following drilling it is not available on a continuous basis.

Most rural water supply boreholes in Africa are drilled by private contractors or Non-Governmental Organisations (NGOs). In general, operating staff have limited technical knowledge and equipment, and often lack basic knowledge regarding the hydrogeological conditions within which they are working. There is also often a lack of effective Government regulation or supervision. Consequently, the quality of workmanship varies considerably, as does the ability to identify, predict and mitigate against possible borehole failure.

This paper is based on research conducted in Ghana in a project area covering parts of Eastern, Ashanti and Brong Ahafo regions, which for the purposes of this study will be known as the Greater Afram Plains (GAP). The study focused on boreholes drilled by World Vision, Ghana between October 1995 and March 2003 under phase III of the Ghana Rural Water Project (GRWP). The research considered 'rapid-onset' borehole failure, or boreholes that fail within seven years of drilling. The focus on boreholes that fail within a few years of construction was based on the crucial need to minimise such occurrences in the interests of efficiency and effectiveness. The study does not preclude the need to address longer-term borehole failure, and findings are likely to remain relevant to both categories.

Rapid-onset borehole failure may have a significant negative impact on members of the user community, who have contributed financially to the construction of the water point and are often trained to ameliorate mechanical problems with the handpump, but have no capacity to resolve borehole problems. Negative effects are felt most strongly during the dry season when alternative water sources are most scarce, and yet, due to lowering groundwater levels, it is at these times that boreholes are most likely to dry up.

Research objective

The study aimed to analyse data routinely collected during borehole drilling and development in order to determine the relationship, if any, between each data variable and subsequent failure of boreholes, and so determine whether these data can be used to predict or mitigate against failure. The focus was on practical field data, as collected and recorded by drilling teams, rather than specialist hydrogeological monitoring data. The rationale behind the selection of these variables was based simply on the likelihood of availability of such data. This data links with the overall objective of identifying existing field practice(s) that may have a detrimental effect on borehole sustainability, in order to recommend any appropriate adjustments to field procedures.

Borehole 'success'

One of the main problems faced in addressing borehole failure is that there is often no clear definition of borehole success at the drilling stage. According to senior staff of GRWP a borehole should only have been deemed successful if at the time of drilling the measured 'yield' was at least 10 litres per minute (l/min). Borehole 'yield' can be loosely defined as the maximum rate at which a borehole can be pumped without lowering the water level in the borehole below the pump intake. It is important to note that this is not the same as the 'safe' or 'sustainable' yield of an aquifer which is an essentially subjective concept (Foster *et al.*, 2000).

The borehole yields recorded by GRWP drilling teams were estimated during a 6-hour constant rate pumping test. The yield was determined by the maximum pumping rate reached within the permitted drawdown for the borehole and handpump. Despite the guideline figure of 10 l/min, in examining borehole records it was noted that in some cases boreholes with measured yields of as low as 7 l/min were classed as 'successful' and were subsequently equipped with handpumps. Consequently all drilled boreholes were classified as either successful or unsuccessful, or 'wet' or 'dry', largely at the discretion of the field supervisor. Where there was no water in the borehole at all, or where there was a very high yield, this task became easy.

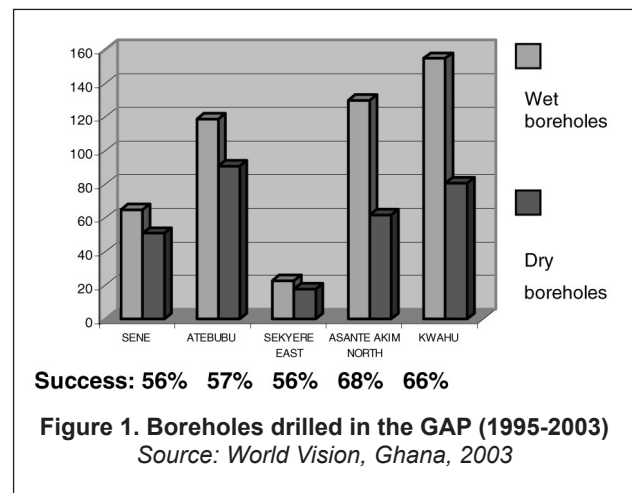
The hydrogeology of the GAP is typified by Palaeozoic consolidated sedimentary rocks, locally referred to as the Voltaian Formation. These consist mainly of sandstones, shales, arkoses, mudstones, laterites and limestones (Gyau-Boakyie & Dapaah-Siakwan, 1999). The Voltaian formation has little or no primary porosity, hence groundwater occurrence is associated with the development of secondary

porosity resulting from jointing, shearing, fracturing and weathering. This has consequently given rise to two main types of aquifer, the weathered zone and the fractured zone aquifers, both of which are found in the GAP. There is no clear demarcation between aquifer types, but where water is held in fracture zones, borehole siting is, in general, a significantly more arduous task than where it is contained in the weathered zone (World Vision, 2003).

All study boreholes were sited by GRWP hydrogeologists. Geophysical surveying methods (electromagnetic EM34 and resistivity) were used for siting in approximately one third of cases. The overall ratio of wet-to-dry boreholes for the five selected districts of the GAP was as follows:

- Wet boreholes drilled: 492
- Dry boreholes drilled: 303
- Overall success rate: 62%

A point of interest is that the overall drilling success rate for Phase I and Phase II of GRWP (1985-1995) in the GAP was 55%, while this rose to 62% for Phase III with the introduction of geophysics for the more difficult sites. Drilling success rates are broken down by district in Figure 1. As can be seen from the graph the success rate in each of the five districts varied from 56% to 68%. These success rates will be revisited later in this paper in relation to subsequent borehole failures.



Since the GRWP drilling programme continued throughout the year, the success rates quoted do not necessarily indicate that these wells remained wet all year round. Several boreholes observed were drilled during the wet season and were reported to dry up in the dry season. This led to water being available for only 6-8 months of the year in some cases. Such situations are classed as examples of where boreholes have 'failed' and are included in this study.

Borehole 'failure'

For the purposes of this study borehole failure is defined as when a borehole, which was recorded as successful, or 'wet' immediately after drilling, subsequently fails to

deliver a sufficient yield of safe water throughout the year. A handpump borehole can be defined as successful if it is able to supply water to a population of 250 people, requiring 25 litres per person per day, where pumping takes place over a 12 hour period (MacDonald *et al.*, 2002). Assuming constant operation of the pump over the 12-hour period this gives a required yield of 8.7 l/min. In order to allow for gaps in pumping and water spillage sufficient yield is defined as 10 l/min. However, for a design population of 250 this still equates to 10.4 hours of pumping which may not be very convenient for users. The value of 10 l/min is therefore set as a **minimum** guideline value only. Wurzel (2001) suggests that the absolute maximum delivery rate of a handpump is 1 cubic metre per hour (m³/hr), or 16.7 l/min, though in reality this is rarely achieved.

It is important to note that a water supply borehole may also be deemed to have ‘failed’ if the water provided by it is unsafe for human consumption. The GRWP Water Quality unit conducted an analysis of the following inorganic (chemical) parameters for each borehole: Na, K, Ca, Mg, As, Fe, Mn, Si (SiO₂), HCO₃, Cl, F, NO₃, PO₄ and NO₂. In total, 306 wells were sampled and analysed in the GAP by March 2003; 94% of those sampled in the GAP satisfied the WHO Drinking Water Guideline values and Ghana Standards Board (GSB) standards for all chemical parameters evaluated. The only parameter of public health concern detected was Fluoride. Fluoride concentrations above the WHO guideline figure and the maximum contaminant limit (mcl) of 1.5mg/l were detected in six boreholes (3%). Since excessive Fluoride can lead to the development of dental and skeletal fluorosis (WHO, 1997) these boreholes were also deemed to have failed. Since the field practices of drilling and development teams cannot have a significant influence on Fluoride concentration, this study focused only on those boreholes that had failed physically, i.e. in which there was insufficient quantity of water.

Borehole or handpump?

The first step in assessing borehole failure is to determine the frequency of the problem in relation to other operational failures. A survey of 492 handpump-equipped boreholes in the GAP was conducted in which all water points were visited towards the beginning of the wet season (March 2003) and those that failed to deliver adequate water were assessed to determine whether this was due to mechanical failure of the pump or failure of the borehole. This survey indicated that 64 point sources and hence 13% of all water points had failed. This is a relatively low failure rate for a project which has been running for seven years (in comparison to the figures quoted in the introduction) and is testament to the committed ongoing support provided to communities by World Vision Ghana. The water point survey produced the following results:

- Total number of water points visited: 492
- Total number of failed handpumps: 42
- Handpump failure rate: 8.5%

- Total number of failed boreholes: 22
- Borehole failure rate: 4.5%

The results indicate that the failure rate for handpumps was almost double that for boreholes. However, where a handpump had failed it was not possible to determine whether or not the borehole had also failed, which means that the proportion of failed boreholes may have been higher than that indicated. This means that in the case of GAP rapid-onset borehole failure accounted for **at least** one-third of all water point failures, which makes it a significant problem.

Variables investigated

In order to determine the possible causes of borehole failure, the following variables were analysed for each borehole. These were:

- Initial recorded yield of borehole;
- Borehole depth in relation to dynamic water level;
- Depth of cylinder below dynamic water level; and
- Season during which drilling took place.

These criteria were based on existing field data, to discover whether there are ‘hidden’ clues, which can help determine the possible causes of borehole failure. Due to incomplete construction and assessment data for some boreholes, the total sample size was reduced to 302.

In addition to the above variables, the borehole failure rate in each district was compared to the respective borehole siting success rate to determine if there was any correlation between the two factors. Since boreholes in the study area were drilled over a seven-year period the age of failed boreholes was also analysed to determine the percentage of boreholes drilled each year that subsequently failed. This was used to determine whether there was an overall trend in increasing failure with age, as would be expected.

The quality of borehole installation (Photograph 1) was not considered as a variable since all boreholes were drilled, developed and constructed following consistent practice by GRWP drilling teams, consisting exclusively of World Vision employees. Random assessments indicated that the quality of workmanship was of a consistently high standard. Also, the study aimed to analyse routine or commonly available field data using a replicable process, and since borehole cameras are not widely available in rural Africa, their use was precluded in the study.

One major criticism of the approach described is that it does not consider the hydrogeological conditions in which different boreholes are drilled. The reasons for this are two-fold. Firstly, this information is often simply not available and personnel engaged in drilling may have limited understanding of the geological environment in which they are operating. Secondly, the time and resource constraints under which drilling teams are operating demand practical strategies to mitigate against borehole failure, which do not require hydrogeological expertise. It is accepted that in an ideal scenario, the hydrogeological conditions for each



Photograph 1. Borehole installation

borehole would be assessed fully, but experience shows that there is often a lack of definitive information and expertise to make this feasible (World Vision, 2003). The density of boreholes in the study area was deemed sufficient to ensure that there were both operational and failed boreholes in each major geological zone, but it was not possible to determine local variations in relation to specific boreholes. It should, again, be emphasised that the study focused on practical field actions which may affect source sustainability and which can be rectified relatively easily if required.

Figure 2 presents a summary of the main variables assessed for each borehole, whether failed or operational. The respective mean values are provided for initial recorded yield (Y) in l/min; depth of borehole (D); static (or rest) water level (SWL); dynamic water level (DWL) measured during pumping test; cylinder depth (C); depth of cylinder below dynamic water level (C-DWL); and depth between dynamic water level and the bottom of the borehole (D-DWL), all in metres.

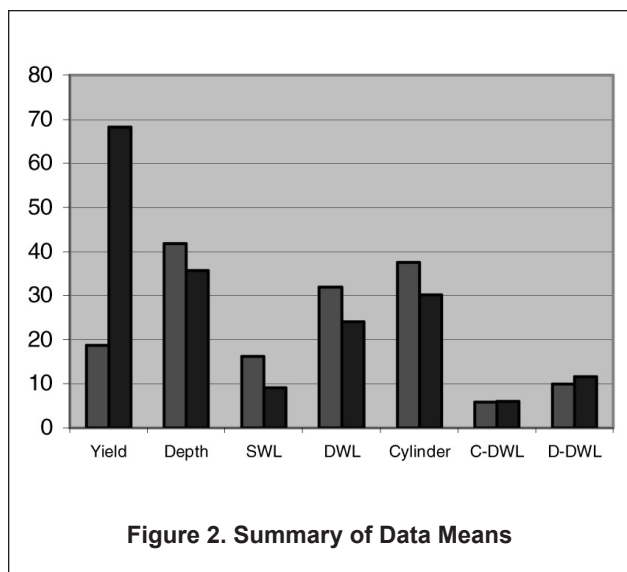


Figure 2. Summary of Data Means

As can be seen from the graph, the most apparent contrast between operational and failed boreholes was the difference between the mean values for initial yield. The mean yield for operational boreholes was 68.2 l/min, while that for failed boreholes was only 18.7 l/min. The variations in depths are less significant, but the mean values for failed boreholes are consistently greater than those for operational boreholes. Means for total depth, static and dynamic water levels are 6-8 metres greater for failed than operational boreholes. The mean value for cylinder depth below dynamic water level (C-DWL) is almost identical for both datasets at 6m, indicating consistent practice among installation teams. Similarly, the mean total depths of borehole in relation to dynamic water level (D-DWL) are very similar. These findings are examined in more detail below.

Initial yield

The initial maximum yield of each successful borehole was measured during and immediately after drilling. The mean maximum yield of 18.7 l/min for boreholes that subsequently failed was a quarter of that for operational boreholes. The respective mode was 10 l/min and the median 15.8 l/min.

The data showed that 40% of all boreholes with initial yields below 10 l/min, and which were deemed ‘successful’ following drilling, subsequently failed. This is significantly higher than the overall borehole failure rate of 4.5%, and indicates that this guideline figure should not be ignored.

The Government Community Water and Sanitation Agency (CWSA) has recently proposed new guidelines which stipulate that boreholes to be fitted with handpumps should have a minimum yield of 13 l/min, rather than the previously stated figure of 10 l/min (CWSA, 2003). Table 1 summarises the yields of the failed boreholes in each district in relation to the new threshold.

From the data available it can be seen that 45% of all the failed boreholes recorded had yields of less than 13 l/min but more than 10 l/min at the time of development. However, that yields should be relatively low is to be expected and caution should be taken in drawing conclusions. The total number of successful boreholes with yields between 10 and 13 l/min in the five selected districts was 85, while the total number of failed boreholes with low yields was 10. This indicates that only 12% of the total number of boreholes with yields between 10 and 13 l/min at the time of development subsequently failed. Therefore, adopting the CWSA standard for the selected areas would result in significantly fewer failures (10) but considerably more un-utilised but seemingly perfectly adequate boreholes (75). This indicates that the new figure is not likely to be a cost-effective measure in reducing borehole failure, since the number of abandoned boreholes is likely to increase significantly, meaning that ‘wasted’ drilling costs would far outweigh any potential benefit to a relatively small number of communities. Even where a drilled borehole has insufficient yield and a replacement borehole is rapidly drilled, there is no guarantee that this will have sufficient yield, meaning that a community might remain without an improved water supply all together.

District	Total no. of failed boreholes	No. of failed boreholes with yield 10-13 l/min	Total no. of boreholes with yield 10-13 l/min
Sene	11	6	18
Atebubu	8	3	33
Sekyere East	0	0	5
Asante-Akim N	2	1	22
Kwahu N & S	1	0	7
TOTAL	22	10	85
% of failed boreholes with initial yields between 10 and 13 l/min:		45%	
% of boreholes with initial yields between 10 and 13 l/min that subsequently failed:			12%

District	No. of failed boreholes drilled in wet season*	No. of failed boreholes drilled in dry season	Total no. of failed boreholes
Sene	10	1	11
Atebubu	6	2	8
Sekyere East	0	0	0
Asante-Akim N	2	0	2
Kwahu N & S	1	0	1
TOTAL	19	3	22
Percentage of failed boreholes drilled in the wet season			88%

* Wet season is taken as from 1st February to 31st July

Relative depths

Further variables addressed in the study were the depth of the borehole, static water level, dynamic water level and the depth to the handpump cylinder. These figures do not reveal a great deal other than the fact that, on average, failed boreholes are deeper than operational ones due to lower static and dynamic water levels, and hence average cylinder depths are also greater. The average depths of the cylinder and base of the borehole below the dynamic water level (C-DWL and D-DWL) would appear to have no bearing on whether a borehole fails in this case, since the values are almost identical for both borehole categories. What may be most significant is the relationship between borehole yield and depth, which indicates that the difference in depth does not compensate for the vast difference in yield. This suggests that boreholes with low yields should be drilled to greater depths below the DWL than those with higher yields. This was not being done in the study area.

Seasonal drilling

To provide a realistic picture of borehole sustainability, pumping tests should ideally be undertaken at the peak of the dry season, when water levels are at their deepest (MacDonald *et al.*, 2002). In practice, however, pumping tests are conducted immediately after drilling while the drilling team is still on site.

World Vision's drilling programme under GRWP was operational throughout the year and consequently boreholes were drilled in both the wet and the dry seasons. Table 2 shows the breakdown of borehole failures by season.

The table indicates that 86% of those boreholes that failed were drilled during the wet season. Based on proportional time periods and the fact that roughly equal numbers of boreholes were drilled in each season, this figure should be only 50% (corresponding to 6 months of the year). This indicates that wet season drilling is approximately six times more likely to lead to borehole failure than dry season drilling.

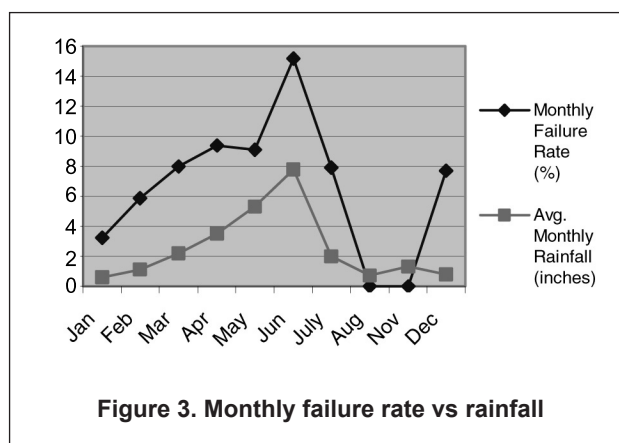


Figure 3 shows the pattern of average monthly rainfall figures in relation to the proportion of failed boreholes as a percentage of all boreholes drilled for each month of the year. The months of September and October were excluded due to an inadequate sample size for each month, with only 2 and 6 boreholes respectively. The precipitation figures used are average monthly totals, rather than actual totals for precise months when drilling took place.

The graph demonstrates a clear relationship between the wettest months and highest failure rates, and the correlation coefficient for this relationship is strongly positive ($r = 0.865$, $df = 9$, $p < 0.01$). This reinforces the finding that wet season drilling is considerably more likely to lead to borehole failure than drilling during the dry season, and suggests that drillers were not making sufficient steps to take seasonal fluctuations in water levels into account during operations. The consistent depth of cylinder installation with respect to DWL, regardless of time of year, supports this assumption. Wurzel (2001) suggests a systematic approach whereby drillers drill an additional 10 metres after sufficient yield is attained to allow for seasonal variation. It is not clear, however, how effective this measure is in countering seasonal water table fluctuations, since the approach was not adopted by the GRWP drillers.

Siting and failure rates

The relationship between borehole siting success rate and borehole failure rate by district is illustrated in Figure 4.

The purpose of this analysis was to determine whether or not rapid-onset borehole failure is more likely in hydrogeologically complex zones, i.e. those areas where borehole siting rates are low. The graph shows a weak inverse relationship between the two variables, which is reinforced by a relatively weak negative correlation ($r = -0.48, df = 4, p < 0.001$). This illustrates that districts with low siting success rates are marginally more likely to have high borehole failure rates, but this relationship is not particularly strong. This can be seen from the example of Sene and Sekyere East districts, which both had borehole siting success rates of 56%, and yet Sene had 11 failed boreholes and Sekyere East had none.

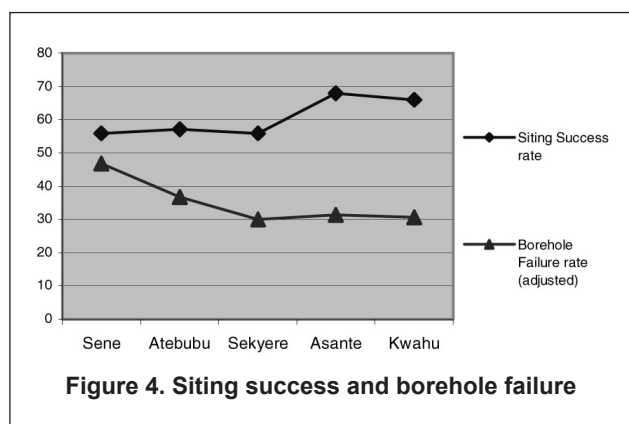


Figure 4. Siting success and borehole failure

Failure over time

It is a logical expectation that the number of failed boreholes will increase with age, and this can be seen in Figure 5. The annual failure rate reduces with decreasing age, so that no failed boreholes were drilled in 2001 and 2002, while there was a maximum number drilled in 1996 (only a very small number of boreholes were drilled in 1995). This suggests that boreholes take at least one or two years before they ‘fail’, and failure rates increase considerably from five years. It should be noted, however, that the survey of water points was conducted during March when the wet season had already started, so it is possible that some ephemeral boreholes contained water that had not done so during the recently ended dry season. This means that the actual total of failed boreholes may be even higher than indicated.

Discussion

Borehole sustainability, or lack of it, is rarely given significant attention in rural water supply programmes in Africa. Whilst it is not as severe a problem as inadequate handpump operation and maintenance, it does have potentially serious and negative effects on rural communities. In order to obtain detailed information as to why boreholes are failing, thorough assessments of construction and installation are required using borehole cameras. This is an expensive option and without strong institutional will it is not likely to happen in most rural African contexts. Routine field data cannot

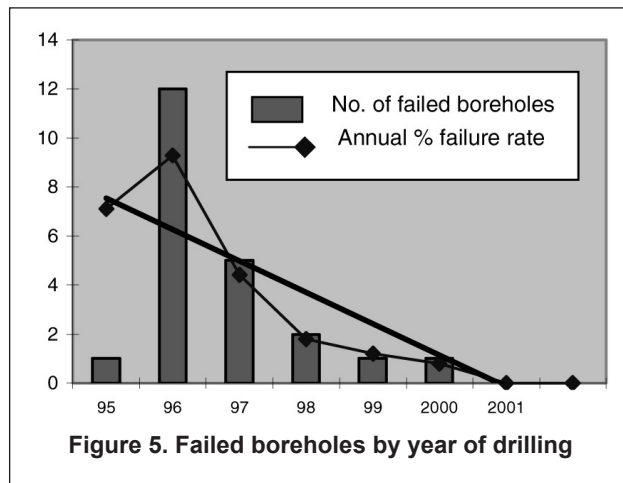
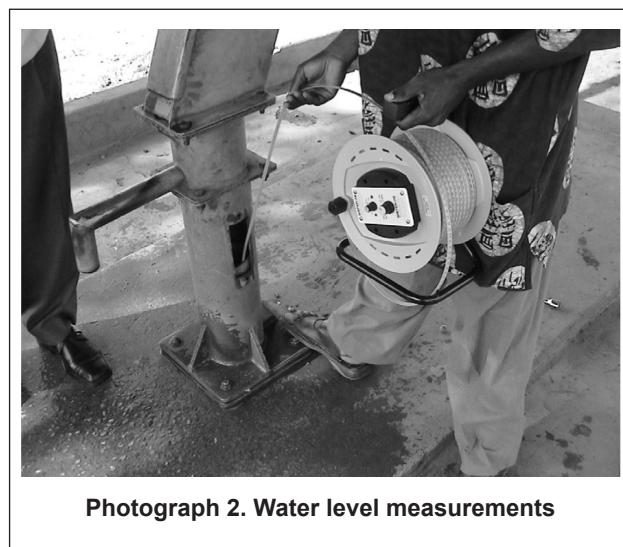


Figure 5. Failed boreholes by year of drilling

provide all the answers, but they can provide indicators to aspects of field practice which can be improved to increase sustainability.

Without longitudinal data on groundwater levels it is impossible to determine whether borehole failures are related to groundwater depletion trends. World Vision, Ghana has now recognised this problem and has recently introduced a system for quarterly monitoring of groundwater levels in boreholes. This is of crucial importance if we are to understand more about the hydrogeological environments in which we work, and to discover why systems fail. Many conventional handpump models do not facilitate easy monitoring of groundwater, and yet an inspection panel can be easily incorporated into existing designs, as used in Ghana (Photograph 2).



Photograph 2. Water level measurements

Conclusions

In order to find out more about borehole sustainability the simple solution is to obtain more hydrogeological information about the areas in which drillers are operating, and to employ more highly qualified and experienced personnel. The reality is, that this is often not possible and there are likely to always be contractors who do a reasonably competent

technical job, but who do not have the level of knowledge required to gain a detailed understanding of hydrogeology. Most drillers, whether NGO or private contractors, record routine field data, such as that described, during water borehole drilling and development. This study examines whether this field data can be used to help predict borehole sustainability. The research findings suggest that there is, indeed, a limited amount of useful information that can be deduced from this data, the key points being:

- The initial measured yield of a borehole is the single largest factor that influences subsequent borehole failure. It is important that realistic guideline figures are set and adhered to. Boreholes with low yields should be drilled to greater depth with respect to DWL (and have longer screened intervals) than those with higher yields, rather than adopting a uniform approach.
- Rainfall intensity during the month of drilling has a direct influence on failure rates. It is essential that where drillers operate throughout the year, they develop compensation strategies for seasonal drilling. This is likely to involve drilling to greater depth in relation to DWL during the wet season, but groundwater levels must be recorded in order to develop appropriate strategies for different geological environments.
- Borehole failure increases with age and is most common at five years old or more, suggesting that most borehole failures are associated with reduction in yields and degradation of well construction over time.
- The siting success rate in a given area does not have a strong affect on the borehole failure rate in that area. It should not, therefore, be assumed that areas of complex hydrogeology will result in higher failure rates.

On the basis of the results obtained it is important that drillers develop field practices which take full account of seasonal groundwater variations and low borehole yields. The people involved in groundwater development must have the skills and knowledge required to be effective, so that they can acquire a real understanding of the environment in which they operate, rather than just follow rigid operational guidelines. The required yield should be matched to forecasted water demand for each specific borehole, based on the population and water usage, rather than using a fixed arbitrary guideline value. Drilling practitioners must pay special attention to low pH water and it is essential that pH values are measured both prior to construction and after development. While there are a range of techniques that can be used for borehole rehabilitation, such as acid treatment, chlorination, and hydrofracturing, the cost and management needs associated with these are often prohibitive. Prevention is better than cure, but this requires appropriate monitoring and information management.

We are now in a situation where many thousands of boreholes have been drilled in sub-Saharan Africa and little knowledge has been gained from them (MacDonald & Davies, 2002). What information we have must be used

to its maximum potential, and further information should be collected and managed, in order to ensure sustainable development, on all fronts.

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Appendix D

Area Development Program (ADP) Advantages

- ***They are more sustainable.*** Community members participate from the beginning, increasing their motivation to protect and maintain their water supplies. And after World Vision leaves, the village-level institutions they have established with our assistance will ensure the gains they have made will last without our continuing support.
- ***They are more transferable.*** World Vision can replicate this model in many water-poor areas, as demonstrated by our successful large-scale water initiatives in Africa, because our ADP model easily accommodates differences in context within and among countries.
- ***They are more holistic.*** We work with communities to address all their primary needs, not just water. We begin with the top needs identified by the community, which often include water provision, but add other sectors as community interest and resources allow. When WASH is integrated with other sectors such as health, nutrition, agriculture, education, and microenterprise development, other benefits accrue to the community in terms of recaptured time, energy, and income, as well as improved personal health and safety. Microenterprise development, for instance, is a key element of our sustainability strategy for WASH. We provide the entrepreneurial poor with microloans and other financial services. Income from small businesses enables the poor to pay fees for accessing the well, which in turn guarantees that funds are available for pump maintenance, repair, and eventual replacement.
- ***They are more impactful.*** Research has demonstrated that a holistic (integrated) approach that includes WASH as a primary element is particularly effective in reducing child illness and death rates. World Vision's 7-11 health/nutrition strategy is an excellent example of the overall benefits of implementing WASH within our ADPs. By combining 7-11 interventions synergistically with WASH and the other primary sectors, we can expect a reduction in overall child deaths of as much as 70 percent in the target areas. The 7-11 strategy is funded by child sponsorship dollars and is at work in virtually all ADPs where WASH interventions are planned or under way.
- ***They are more effective.*** We leverage key partnerships to increase the financial and technical resources available. For instance, we collaborate with cutting-edge research organizations—from the Water Research Institute in Ghana to the Desert Research Institute in Nevada. And we listen to our local and national partners because they understand best the needs of their communities.

World Vision also addresses HIV and AIDS in high-prevalence areas through our ADP structure. The ADP platform also enables us to address local instances of social injustice such as widow abuse, child labor, sex trafficking, or the special needs of the physically disabled. In addition, where our Christian identity can be fully expressed, World Vision seeks to intertwine social and livelihood transformation with spiritual transformation.