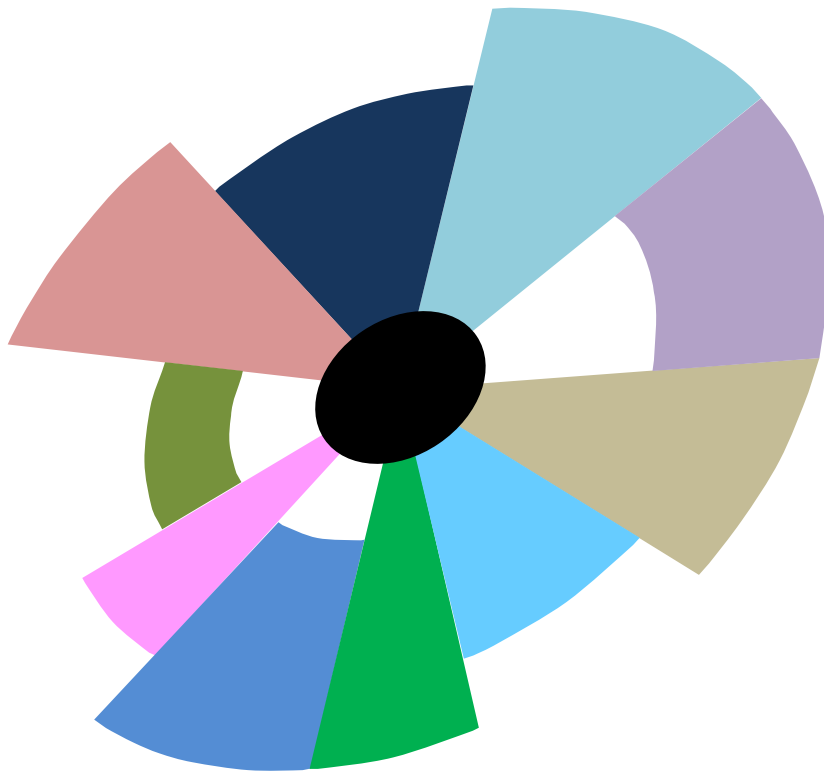

WATER SAFETY PLAN

FOR
SIDKO ARSENIC REMOVAL
TECHNOLOGY



BETV-SAM



DPHE



ITN

JUNE, 2007

Introduction

A draft of this first edition of a water safety plan (WSP) for the SIDKO Arsenic Removal Technology (ART) was prepared in 2006 and presented on April 10, 2007 at the “Review Workshop on the Implementation and Development of Water Safety Plans” workshop that was held in Dhaka and organised by WHO and DPHE in cooperation with BETV-SAM and ITN-BUET. During the workshop, representatives from government, NGO and development partner organisations participated in review sessions and provided valuable comments and suggestions regarding the draft WSP. Version 1.0 of this WSP was then finalised in June 2007 and provided for use in Bangladesh.

If a government or non-government organisation that applies this WSP for the SIDKO ART feels that minor changes are required based on their own water supply system, the concerned organisation should maintain a record of all the changes on the following sheet.

Document Change Record Sheet

Location	Changes made	Remarks

Table to be completed, as necessary, to keep track of any changes that are made to the WSP in the future.

Pro-formas

Table 1. The WSP team.

The first step of implementing the WSP is to form a team of people from the implementing organisation/s working on water safety plans for ARTs. It is preferred that the team will include people from different disciplines and those having commitment and technical ability to develop and implement the WSP.

Name	Affiliation	Title	Role in WSP team	Contact Information			
				Address	T	F	E

The WSP documents are dynamic documents. As new information and experience becomes available about the SIDKO ART or the performance of the WSP, the document can be improved and modified to reflect these changes. Therefore, the implementing organisations should assign a person who will be responsible for updating the WSP and disseminating it to WSP team members through a set process of the organisation.

Document development history:

Version	Date
1 st version	June 2007 by BETV-SAM

Document Approved by: Name: _____

Date: _____

Table 2. Water supply process description.

Step	Description
Water source	Abstraction from groundwater via a tubewell that is fitted with an electric motor and centrifugal pump, and a hand pump, that are used for collection of untreated water. The water is pumped into an overhead stainless steel raw water tank. The hand pump can be used to fill the overhead raw water tank when there is no electricity to operate the centrifugal pump.
Water treatment process	Water flows down from the overhead raw water tank through an iron removal filter (media housed in a mild steel tank) and then an arsenic removal filter (a mild steel tank containing AdsorpAs® media) before collecting in a stainless steel treated water storage tank.
Storage of treated water	The treated water collects in the stainless steel treated water storage tank.
Distribution of water	Water is collected directly from a tap on the treated water storage tank, as a point source. However, in the future, water from SIDKO community-scale units may be connected to a piped water distribution system.
Collection and storage of treated water by individual household members	Water is collected from the SIDKO ART, generally using clay or metal pitchers, and either directly consumed from the pitcher or transported to the kitchen area in the individual household for storage and use (may include transfer between containers).
Operation and Maintenance (O&M) controls required	<p>At installation, a platform is constructed using bricks and cement, the tubewell is equipped with a centrifugal pump and hand pump, a steel structure is constructed and the SIDKO ART (including tanks and pipes) is installed. The iron removal media and arsenic removal media are washed prior to operation. The designated caretaker(s) of the SIDKO ART is provided with training from the proponent, and hygiene/sanitation education.</p> <p>To operate the SIDKO ART, the caretaker primes the centrifugal pump and fills the overhead raw water tank when necessary. The operator ensures that the appropriate valves are open to allow water to flow through the iron and arsenic removal filters and collect in the treated water storage tank. The caretaker performs ART maintenance, including regular backwashing of the iron removal filter.</p> <p>Further details are provided in the SIDKO Operations and Maintenance manual (attached).</p>
Treated water quality requirements	Water quality should comply with the Bangladesh drinking water standard for arsenic (GoB, 1997), and the WHO drinking water quality guidelines for other parameters.

Table 3. Intended uses of water and nature of consumers, information capture form.

Intended Use	Intended Consumer
<ul style="list-style-type: none"> • Water is collected from the treated water storage tank of the SIDKO ART and is used for drinking and cooking purposes. • A caretaker is responsible for the operation and maintenance of the SIDKO ART. • Water should meet safety and quality (aesthetic) standards i.e. Bangladeshi drinking water standard for arsenic (GoB, 1997) and WHO drinking water guidelines for other parameters: • Safety requirements: <ul style="list-style-type: none"> • Arsenic • <i>E. coli</i> and sanitary inspection score • Nitrate • Manganese • Turbidity • etc. • Aesthetic requirements: <ul style="list-style-type: none"> • Iron • Chlorine (residual) • Odour • Taste • Colour • Turbidity • etc. 	<ul style="list-style-type: none"> • The users are people residing in arsenic-affected areas and include the healthy, young, old, pregnant, disabled and immune-compromised. • The caretakers of SIDKO ARTs require technology-specific and sanitation training in order to operate and maintain the ART properly. • The users transport treated water from the SIDKO ART in pitchers that may not be clean and/or may store the water in unsanitary conditions, thereby increasing the risk of microbial contamination. Controlling these risks requires hygiene education about the safe water chain by hygiene education staff working at the Union and Upazila level. • The SIDKO ARTs should be monitored and inspected (as outlined in “Table 7: Operational Monitoring Schedule”) according to a regular schedule.













Table 4. Technology description (should be supported by community water and sanitation maps prepared for individual communities and sanitary surveys).

To be completed by each organisation applying WSP for SIDKO ART

Issue	Information	Attached documents
Verification certificate information	The SIDKO ART received provisional verification for deployment in Bangladesh. With new media, the ART can be operated for 6 months to produce 121,500 L of arsenic-safe water where influent water contains arsenic $\leq 500 \mu\text{g/L}$, iron $\leq 10 \text{ mg/L}$, phosphate $\leq 4 \text{ mg/L}$, and pH ≤ 7.5 .	ETV-AM Provisional Technology Verification Statement
Standard design	<p>The source tubewell is equipped with an electric motor and centrifugal pump and a hand pump.</p> <p>The SIDKO ART is installed on a platform that is constructed with bricks and cement and is approximately 96" (243 cm) \times 108" (274 cm).</p> <p>The SIDKO unit includes an overhead stainless steel raw water tank, an iron removal filter (media housed in a mild steel tank), an arsenic removal filter (a mild steel tank containing AdsorpAs[®] media), and a stainless steel treated water storage tank. The tanks and filters are connected by tubes that are fashioned with valves.</p> <p>The ART is protected by a steel structure/cage that includes a plastic cover/roof.</p>	SIDKO Adsorp-As [®] Arsenic Removal Technology Operation and Maintenance Manual
System capacity specifications and people served by ART	The SIDKO ART can treat approximately 240 litres of water per hour, which is enough to serve 50 households, each with 40 litres of arsenic-safe water per day. The source tubewell must be able to provide the required volume of raw water.	SIDKO Adsorp-As [®] Arsenic Removal Technology Operation and Maintenance Manual
Materials specification	The Adsorp-As [®] media is imported from Germany. The other SIDKO ART materials, including the 2 stainless steel water storage tanks, the 2 mild steel tanks that house the media, and the pipes and valves are available and manufactured in Bangladesh.	
Usual setting	The SIDKO ART must be installed at a tubewell that is accessible for community use, and can supply the required volume of water.	
Source protection measures required	Establish and maintain safe distances for use of fertilizers and locations of latrines.	

Issue	Information	Attached documents
Requirements to characterise well prior to installation of ART	Prior to installation of ART, well characterisation samples are analysed to ensure that the tubewell complies with the deployment conditions outlined in the Verification Statement and the WHO drinking water quality guidelines for concentrations of manganese, boron, etc.	ETV-AM Provisional Technology Verification Statement
Operation and maintenance requirements	<p>To operate the SIDKO ART, source tubewell water is pumped into the overhead raw water tank. Water flows through the iron removal filter and the arsenic removal filter, and accumulates in the treated water storage tank. The ART is operated by a designated caretaker(s).</p> <p>Regularly scheduled maintenance that the caretaker performs includes:</p> <ul style="list-style-type: none"> • backwash the iron removal filter daily, • drain the overhead raw water tank at least once every two weeks, and • backwash the arsenic removal filter approximately every two months. <p>The arsenic removal media must be replaced according to the verification certificate schedule.</p>	SIDKO Adsorp-As® Arsenic Removal Technology Operation and Maintenance Manual
Training requirements	As outlined in the Technology Verification Statement, the proponent is required to train at least one user (the designated caretaker) of each SIDKO ART on the installation, operation and maintenance of the unit.	ETV-AM Provisional Technology Verification Statement

Table 5. Process flow diagram for the use of ARTs.

Code	Step	Description	Responsibility
ART1		Catchment	Agencies, community
ART2		Source - tubewell	Community, caretaker
ART3		Centrifugal pump and hand pump	Caretaker
ART4		Transfer and storage (tubewell to raw water overhead tank)	Caretaker
ART5		Transfer (from overhead raw water tank through ART)	Caretaker
ART6		Treatment (iron removal filter)	Caretaker
ART7		Treatment (arsenic removal filter)	Caretaker
ART8		Storage (in treated water tank)	Caretaker
ART9		Collection of treated water (in pitchers, from ART taps and outlet)	Household
ART10		Transport (from ART to household)	Household
ART11		Storage (at the point of use)	Household
ART12		Use (drinking and cooking)	Household

Symbols:






Key:		Storage		Operation		Inspection
		Transport		Delay		

Table 6. Hazard analysis.

Process Step (code from pro- forma 5)	Hazardous Event	Hazard Type	Existing Control Measures	Risk ¹	Additional Control Measures Required to Help Reduce Risk
ART0 Social exclusion	Poor members of community excluded from use of ART because of income, gender or other social barriers	Social	Ensure that all members of the community are involved in water supply development from start	U	Design programmes with involvement from the communities in water supply development
ART1 Catchment around source	Leaching from over-application of fertilisers or organic waste dumps	Nitrate and nitrite	Fertilisers not used within at least 10m of the well, and waste dumps located at least 10m from the well	U (STW) I (DTW)	Community discussion to agree on minimum distance for fertilizer use and waste dumps
	Faecal contamination through sub-surface leaching from human or animal wastes	Microbial (B,V) nitrate	Prevent open defecation by community, ensure latrines located acceptable distance (if not specific guidance then use 10m from well as a default), prevent animal yard/pen within 10m of well, and provide fence around tubewell	S (STW) U (DTW)	Promote sanitation within the community. Establish minimum safe distance for latrines and animal pens (check with DPHE or NGO) and agree with community to keep faecal material away from the well. Ensure fence does not prevent access for some members of community.
ART2 Source - tubewell	Ingress of contaminated water through cracks and mouse burrows undercutting the platform	Microbial (B,V,P)	Platform is of sufficient size and properly maintained to prevent flow-paths developing; fence surrounds tubewell	S	Ensure correct mortar mix used and make repairs when required
	Ingress of contaminated water through poorly sealed rising main	Microbial (B,V,P)	Ensure top 5m of annulus properly sealed	S	Monitor construction quality and materials specification
	Entry of contaminated stagnant water due to poor drainage	Microbial (B,V)	Spill water is properly drained away from the tubewell platform	S	Ensure apron properly constructed and repair cracks. Dig drains around well and keep clean. Motivation for sanitation improvement in community.
	Ingress of contaminated surface water during flooding	Microbial (B,V,P)	Ensure the tubewell is raised above the flood level, remove pumps during flooding, and chlorinate wells if they are flooded	S	Ensure proper drainage around tubewells, provide emergency response programmes during disaster, and encourage well owners to chlorinate wells after flooding
	Concentrations of harmful inorganic contaminants in the tubewell water, <i>other than arsenic and iron</i> , exceed the WHO drinking water quality guidelines spill	Chemical and physical contaminants	Prior to selection and installation of the ART, well characterisation samples are collected and analysed to ensure that, <i>except for arsenic and iron</i> , the tubewell water is safe. If concentrations of manganese and/or boron exceed the WHO guidelines, the tubewell should not be used and another tubewell should be selected as the drinking water source.	U	Promote the importance of sampling wells, reviewing ART deployment conditions and selecting appropriate ARTs
Process Step	Hazardous Event	Hazard Type	Existing Control Measures	Risk ²	Additional Control Measures Required to Help

¹ Risk type: S = significant, U = uncertain, I = insignificant

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(code from pro-forma 5)					Reduce Risk
ART2 continued... Source - tubewell	Water quality of tubewell is not sufficiently assessed and compared to deployment conditions attached with the ART Verification Certificate, prior to selecting the type of ART	Arsenic contamination due to inappropriate ART selected for the tubewell	Ensure that the water quality data from the tubewell is reviewed and concentrations of key water quality parameters comply with the following requirements: <ul style="list-style-type: none"> • arsenic \leq 500 μg/L • iron \leq 10 mg/L • phosphate \leq 4 mg/L • ph \leq 7.5 	U	Promote the importance of sampling wells, reviewing ART deployment conditions and selecting appropriate ARTs
ART3 Centrifugal pump and hand pump	Contamination introduced through use of contaminated priming water for pump	Microbial (B,V,P)	Ensure pump foot valve in good condition and ensure only clean water is used to prime pumps	S	Install new seat valves when necessary
	Microbial contamination of water that is pumped into overhead raw water tank	Microbial (B,V,P)	Ensure pumps are powerful enough to pump tubewell water directly into the overhead raw water tank, and the piping system is clean and sealed. If hand pump is used, ensure spout is clean and caretaker practices good hygiene	U	Repair any leaks to piping system when necessary and schedule use of centrifugal pump to fill overhead storage tank during periods when electricity is available
ART4 Transfer and storage (raw water overhead tank)	Microbial contamination of water in the raw water overhead tank due to ingress of faecally contaminated materials such as bird drops, vermin, etc. into the tank	Microbial (B,V,P)	Ensure that the overhead raw water tank is kept covered and sealed, and the caretaker performs regularly scheduled inspections of the tubewell, pipes and tanks.	S	When ART is installed, the designated caretaker(s) is (are) provided with an O&M manual and appropriate training from SIDKO to ensure that: <ol style="list-style-type: none"> 1. the ART is operated according to the proponent's requirements 2. the ART unit undergoes regular inspection and maintenance (including backwashing of the media) 3. the media is replaced according to the prescribed schedule, only with media that is supplied by the proponent A follow-up program to monitor the effectiveness of the training is recommended. Also ensure that the caretaker(s) of the ARTs is (are) provided with hygiene and sanitation education, especially with respect to ART operation and maintenance.

² Risk type: S = significant, U = uncertain, I = insignificant

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Process Step (code from pro- forma 5)	Hazardous Event	Hazard Type	Existing Control Measures	Risk ³	Additional Control Measures Required to Help Reduce Risk
ART5 Transfer (from overhead raw water tank through ART)	Microbial contamination of water in the ART due to leakage in the pipes and potential ingress of faecally contaminated materials such as bird drops, vermin, dust, etc.	Microbial (B,V,P)	Ensure that all pipes and tanks are sealed, clean and free from contamination, the caretaker performs regularly scheduled inspections of the tubewell, pipes and tanks.	S	As discussed above, caretaker(s) is (are) provided with O&M manual and appropriate training, including hygiene and sanitation education
ART6 – ART7 Treatment (iron and arsenic removal filters)	The ART does not perform satisfactorily, and produces treated water with concentrations of As > 50 µg/L or other contaminants (iron, turbidity, etc.) that exceed the WHO drinking water quality guidelines due to fouling of the ART media (specifically with iron) and improper operation and maintenance	Arsenic and chemical contamination due to fouled media	Ensure that the ART is operated (including proper startup and media washing procedures) and maintained (including daily backwash of the iron removal filter media and regular wash of the overhead raw water tank) according to the requirements of the SIDKO ART operation and maintenance (O&M) manual	S	As discussed above, caretaker(s) is (are) provided with O&M manual and appropriate training, including hygiene and sanitation education
ART7 Treatment (arsenic removal filter)	The ART does not perform satisfactorily, and produces treated water with concentrations of As > 50 µg/L due to failure to replace the Adsorp-As® arsenic removal media as required	Arsenic contamination due to failure to replace the media on schedule	Ensure that the ART is operated (including proper startup and media washing procedures) and maintained (including regular backwash of the arsenic removal media) according to the SIDKO ART O&M manual. Replace Adsorp-As® arsenic removal media every 121,500 litres of treated water produced, as per the deployment conditions in the technology verification certificate.	S	As discussed above, caretaker(s) is (are) provided with O&M manual and appropriate training, and encouraged to monitor the volume of water treated to identify when media replacement is required
ART8 Storage (in treated water storage tank)	Microbial contamination due to improper operation and maintenance of the ART	Microbial (B,V,P)	Ensure that good hygienic practices are followed by the caretaker(s) during operation and maintenance of the ART, including cleaning of the water collection spouts on the treated water storage tank, ensuring that all pipes are sealed and free from sources of contamination, and flushing the media with chlorinated water (as outlined in the O&M manual) in response to complaints or if results of sanitation surveys suggest contamination of the ART	S	As discussed above, caretaker(s) is (are) provided with O&M manual and appropriate training, including hygiene and sanitation education

³ Risk type: S = significant, U = uncertain, I = insignificant

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Process Step (code from pro-forma 5)	Hazardous Event	Hazard Type	Existing Control Measures	Risk⁴	Additional Control Measures Required to Help Reduce Risk
ART8 continued... Storage (in treated water storage tank)	Aesthetic concerns such as colour, taste, odour, etc. of the treated water	Physical contaminants	Ensure that the ART is operated and maintained according to the O&M manual, including discarding the water from washing the media and backwashing procedures, and draining the treated water tank if required because the ART has not been used for a few days or if the treated water has poor aesthetic quality	U	As discussed above, caretaker(s) is (are) provided with O&M manual and appropriate training, including hygiene and sanitation education
ART9 Collection of treated water (in pitchers, from ART taps and outlet)	Collect water in unsanitary container	Microbial (B,V,P)	Clean and/or disinfect water container regularly with ash (Bangladesh rural context), detergent or soap, and rinse well with clean water	S	Provide hygiene education to the community, stressing the importance of cleanliness and sanitation
	The collector does not practice good sanitary practices (such as dipping his/her fingers into collected water, etc.)	Microbial (B,V,P)	Ensure that vessel is put close to the outlet spout to allow direct entry of water into the collection container and to ensure that water does not come into contact with any possible sources of contamination such as hands, utensils, etc. Also, sanitize the tap and outlet spout regularly to keep it clean and free from contamination	S	Provide hygiene education to the community, stressing the importance of cleanliness and sanitation
ART10 Transport (from ART to household)	Water becomes contaminated during transport in an uncovered container	Microbial (B,V,P)	Ensure that vessel has a cover that is used during transport from the ART to the household	U	Provide hygiene education to the community, stressing the importance of cleanliness and sanitation
ART11 Storage (at the point of use)	Water becomes contaminated during transfer of water from transport container into a contaminated storage container	Microbial (B,V,P)	Clean and/or disinfect storage container regularly with clean water and soap, and ensure that water does not come into contact with possible sources of contamination such as contaminated utensils and unclean hands	S	Provide hygiene education to the community, stressing the importance of cleanliness and sanitation
	Water becomes contaminated from people, animals, insects or airborne dust while in storage at the home	Microbial (B,V,P)	Keep the storage container covered at all times and store water container at elevated levels	S	Provide hygiene education to the community
ART12 Use (drinking and cooking)	Water becomes contaminated because unsanitary cups or utensils are used to collect water from the storage container	Microbial (B,V,P)	Clean and disinfect dipper cup that is used to withdraw water from storage container, or tip the storage container to pour water directly into the drinking vessels	S	Provide hygiene education to the community, stressing the importance of cleanliness and sanitation

⁴ Risk type: S = significant, U = uncertain, I = insignificant

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Process Step (code from pro-forma 5)	Hazardous Event	Hazard Type	Existing Control Measures	Risk⁵	Additional Control Measures Required to Help Reduce Risk
ART12 continued... Use (drinking and cooking)	Water contaminated before consumption because unsanitary drinking utensils used, or unclean hands	Microbial (B,V,P)	Use clean cups and utensils, and practice good hygiene	S	Provide hygiene education to the community, stressing the importance of cleanliness and sanitation
ART13 Waste Management	Arsenic from wastes is released into the environment in significant amounts	Environmental pollution	Ensure proper management of arsenic-containing wastes, including exhausted media, sludge and precipitate, etc.	I	Ensure that waste management instruction is provided in the O&M and through training - a follow-up program to monitor the effectiveness of the training is recommended

⁵ Risk type: S = significant, U = uncertain, I = insignificant

Table 7. Operational monitoring schedule.

Process Step	Performance Indicator	Monitoring	Critical Limit	Corrective Action	Supporting Programs
ART1 Catchment around source	Land use close to tubewell	What: Land-use around tubewell	No latrines, animal pens, waste dumps or fertilizers use within 10m of the tubewell	What: Re-siting of latrines, animal pens, waste dumps Stop fertiliser use	Training of community committee and caretaker Education and motivation of communities to change defecation practices
		How: Catchment inspection		How: Use of local by-laws and community dialogue	
		When: Monthly		When: As soon as identified	
		Where: In catchment area (10m radius from well)		Who: Community committee	
ART2 Source - tubewell	Sanitary maintenance of tubewell	What: Condition of platform to check for cracks, burrows and undercutting	No cracks or undercutting of platform	What: Repairs to platform Repairs to fence	Caretaker training and community motivation
		How: Sanitary inspection		How: Repair of concrete works Repair of fence	
		When: Monthly		When: Protection works: within 7 days Fence: within 1 month	
		Where: At the tubewell		Who: Caretaker	
ART2 Source - tubewell	Proper drainage	What: Drainage of water away from tubewell	Drain in good condition and clear of debris	What: Clear debris and make minor repairs	Caretaker training
		How: Sanitary inspection		How: Follow O&M guidance	
		When: Monthly		When: Before monsoon and weekly during monsoon	
		Where: At the tubewell		Who: Caretaker	
ART2 Source - tubewell	Flood protection	What: Level of tubewell, removal of pumps	Tubewell raised above flood level	What: Raise tubewell above the historical flood level As floodwaters rise remove electric pumps if necessary, for safety reasons	Check flood levels with community during design During flooding events, monitor water levels and remove electric pump when necessary
		How: Inspection		How: Increase height of handpump and provide concrete protection of rising main	
		When: As floodwaters rise		When: On commissioning	
		Where: At the tubewell		Who: NGO/DPHE	
Who: Caretaker					

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Process Step	Performance Indicator	Monitoring	Critical Limit	Corrective Action	Supporting Programs
ART2 Source - tubewell	Post flood chlorination	What: Presence of chlorine How: Taste and smell, use of comparator where available When: After chlorination, daily basis Where: At the tubewell Who: Caretaker	Smell and taste of chlorine present If use comparator, at least 0.1mg/L free chlorine	What: Add chlorine following guidelines How: Use recommended practice When: Following flooding and inundation, and/or in response to community/household complaints Who: Caretaker	Caretaker training Chlorination schedule Sanitary maintenance of tubewell
ART2 Source - tubewell	Chemical quality of groundwater used for ART	What: Tests for manganese and other key chemicals (<i>note: not including arsenic or iron</i>) How: Analyse water samples using field test kits and send 5% to analytical lab for confirmation, compare results to ART requirements When: During well selection, prior to ART installation Who: NGO or other organisation providing the ART, in consultation with the community committee	WHO water quality guidelines	What: If tubewell not in compliance, move to an alternative tubewell or safe drinking water source How: Through on-going source water selection process When: During well selection, prior to ART installation Who: Community committee	Develop local capacity to conduct field analyses following SOPs, QA/QC, etc., Develop local analytical lab capacity
ART2 Source - tubewell	SIDKO ART is appropriate for the tubewell	What: Test for concentrations of arsenic, iron and phosphate to ensure that they comply with the deployment conditions for SIDKO ART How: Analyse water samples using field test kits and send 5% to analytical lab for confirmation Compare results to SIDKO deployment conditions attached with the Verification Certificate When: Prior to installation of ART Who: NGO or other organisation providing the ART	Concentrations of key parameters outlined in deployment conditions of the ART Verification Certificate: • arsenic \leq 500 μ g/L • iron \leq 10 mg/L • phosphate \leq 4 mg/L • pH \leq 7.5	What: If the SIDKO ART is not appropriate for the tubewell, move to an alternative tubewell or safe drinking water source How: Through on-going source water selection process When: Prior to installation of ART Who: NGO or other organisation providing the ART	Ongoing screening and ART awareness programs
ART3 Centrifugal pump and hand pump	Priming water use	What: Quality of priming water and inspection of pumps How: Caretaker inspection When: Each time the pump is primed Where: At the tubewell and where priming water stored Who: Caretaker	Clean or no priming water used, pumps in good working condition	What: Control the priming water source, and repair pumps and replace foot valves when necessary How: Pump maintenance When: Within 7 days Who: Caretaker	Caretaker training
Process Step	Performance Indicator	Monitoring	Critical Limit	Corrective Action	Supporting Programs

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ART3 - ART5, ART8 Centrifugal and hand pump, transfer to raw water overhead tank, storage, and flow through ART into treated water storage tank	Sanitary maintenance of pump platform, ART pipes and raw water overhead and treated water storage tanks	What: How: When: Who:	Inspection of tubewell, ART pipes, overhead tank, and treated water storage tank and water hygiene practices Caretaker sanitary inspection Every two weeks Caretaker	Pumps working properly, spout clean, no leaks in the piping system Good operating practices and SIDKO O&M manual	What: How: When: Who:	Repair piping system and clean pipes, tank, etc. when necessary, ensuring that overhead tank is sealed and flush the media with boiling water Perform repairs and maintenance to pipes and tanks Drain the storage tanks and wash with clean water and chlorine, disinfect iron and arsenic removal filters with chlorinated water from the overhead tank Immediately, upon requirement Caretaker	If ART requires maintenance and cleaning, provide refresher training on ART maintenance and hygiene to the caretaker Community and hygiene promoter training
ART6 - ART7 Treatment (iron and arsenic removal filters)	Technical performance: ART producing adequate volumes of treated water	What: How: When: Who:	Process parameters such as daily volume, flow rate, etc. Inspect the caretaker maintenance records and the ART (iron removal filter, etc.), and if necessary measure the flow rate and daily volume of water produced Every two weeks during sanitary inspection, or when a change in performance is observed Caretaker	Process parameters and operating values specified in the ART-specific O&M manual	What: How: When: Who:	Restore ART unit performance Backwash the filter media and perform other maintenance procedures Conducted on a regular basis, as outlined in the ART-specific O&M manual or when poor performance is observed Caretaker	Caretaker is provided with an ART-specific O&M manual and appropriate training
ART6 - ART7 Treatment (iron and arsenic removal filters)	Proper ART-specific maintenance	What: How: When: Who:	Frequency of maintenance requirements such as backwashing, media replacement, etc. Review of caretaker records and comparison to the schedule that is outlined in the O&M manual Inspection and review of the records on a semi-annual basis Community committee	Maintenance schedule, as outlined in the ART-specific O&M manual	What: How: When: Who:	Perform ART maintenance and strengthen the importance of O&M Provide the caretaker with appropriate follow-up training to emphasize the importance of regularly scheduled O&M When inspection results indicate that the ART is not being maintained according to the O&M manual Organised by the community committee, with training provided from available groups such as NGOs providing the ART, SIDKO proponent, etc.	On-going training, as necessary, for the caretaker

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Process Step	Performance Indicator	Monitoring	Critical Limit	Corrective Action	Supporting Programs
ART7 Treatment (arsenic removal filter)	Technical performance: proper replacement of ART media	<p>What: Replacement of ART media according to schedule</p> <p>How: Inspection of flow meter on SIDKO unit to monitor volume of treated water produced (to identify when arsenic removal media should be replaced)</p> <p>When: Inspections conducted every two weeks Media replacement every 121,500 litres of treated water produced</p> <p>Who: Caretaker</p>	Deployment conditions in the ART Verification Certificate – every 121,500 litres of treated water produced	<p>What: Replace the Adsorp-As® media</p> <p>How: Contact the proponent to arrange for new Adsorp-As® replacement media for the ART</p> <p>When: When the volume of treated water produced by the ART (since the last media replacement) is 121,500 litres.</p> <p>Who: Community committee</p>	Provide education and motivation training to the caretaker and community committee on ART deployment conditions and media replacement requirements Maintain up-to-date contact information for the SIDKO proponent
ART8 Storage (in treated water storage tank)	Control of aesthetic water quality	<p>What: Aesthetic quality of the treated water</p> <p>How: Survey by the community committee Discussions between the caretaker and end-users</p> <p>When: Formal surveys semi-annual Discussions with end-users on an on-going basis</p> <p>Who: Community committee and caretaker</p>	<p>WHO drinking water guidelines</p> <p>Acceptable aesthetic water quality, as indicated by end-users</p>	<p>What: Restore ART unit performance</p> <p>How: Backwash the filter media, perform other maintenance, and drain both the overhead raw water tank and the treated water storage tank</p> <p>When: When poor aesthetic water quality is indicated by end-users</p> <p>Who: Caretaker</p>	Caretaker is provided with O&M manual and appropriate training
ART9 - ART12 Collection from ART, transport to the household and storage and use (drinking and cooking)	Hygienic water collection, transport, storage and use	<p>What: Hygienic practice during collection, transport and storage</p> <p>How: Sanitary inspection</p> <p>When: Inspections at the ART every two weeks Inspections in households and community monthly</p> <p>Who: At the ART: caretaker In households: community hygiene promoter, with support from NGOs and the community committee</p>	Water collection, transport, storage and use is hygienic	<p>What: Educate caretakers, households and other end-users on proper hygienic practices</p> <p>How: Hygiene education provided to the community</p> <p>When: On-going and as required, depending upon results of hygiene inspections</p> <p>Who: Community hygiene promoter, with support from NGOs or other organisation</p>	Development of hygiene education materials, training of community and promotion of hygiene
ART13 Waste Management	Compliance with waste management requirements	<p>What: Appropriate disposal of arsenic-containing wastes from the ART (exhausted media, sludge, etc.)</p> <p>How: Conduct inspections of ART records to ensure the proponent collected and removed spent media from site when ART is replaced with new media</p> <p>When: Visual inspection when media replaced</p> <p>Who: Caretaker</p>	Waste management requirements in the ART verification certificate	<p>What: Have proponent remove spent media from the site</p> <p>How: Contact proponent to arrange for media to be collected</p> <p>When: If necessary, when spent media identified</p> <p>Who: Caretaker and community committee</p>	Provide the community committee with information on media replacement requirements Promote DPHE involvement in the process if required

Table 8. Verification schedule.

Activity	Description	Frequency	Responsible Party	Records
Effectiveness of water safety management	Scheduled meetings with WATSAN committee, community committee, and end-users	Semi-annual visits	NGO or ART provider, in coordination with DPHE	Information to be maintained by NGO or ART provider (the local level), and supplied to DPHE (the national level)
Reduction of social exclusion to ARTs	Scheduled meetings with WATSAN committee and/or community committee	Semi-annual visits	NGO or ART provider, in coordination with DPHE	Information to be maintained by NGO or ART provider (the local level), and supplied to DPHE (the national level)
Tubewell inspection	At source selection, inspect tubewell according to WSP requirements	During tubewell selection, prior to installing ART	NGO or ART provider, in coordination with DPHE	Data stored at local levels and transferred to national water supply information centre (in the interim, all data should be submitted to NAMIC)
Testing concentrations of arsenic	Routine well characterisation and monitoring data from 10% of the ARTs is collected using field test kits (with 5% of the samples going to a lab that is suitable to DPHE for confirmation), compiled and analysed to verify the performance of the well selection procedures and the performance of the ARTs	Source: during tubewell selection, to coincide with tubewell inspection ARTs: on a select sample of ARTs throughout the deployment areas	NGO or ART provider, in coordination with DPHE	Data stored at local levels and transferred to national water supply information centre (in the interim, all data should be submitted to NAMIC)
Testing of microbial water quality	Sanitary inspection and thermotolerant coliform analysis on 5% of the tubewells and ARTs using either field kit (DelAgua, Potatest, etc.) or laboratory that is suitable to DPHE Confirmatory testing for <i>E.coli</i> on 5% of positive samples	Source: during tubewell selection and annually on a random selection of tubewells throughout the deployment area ARTs: semi-annual sampling on a random selection (5%) of SIDKO units	NGO or ART provider, in coordination with DPHE	Data stored at local levels and transferred to national water supply information centre (in the interim, all data should be submitted to NAMIC)

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Activity	Description	Frequency	Responsible Party	Records
Sanitation and Hygiene Inspections	In conjunction with the microbial testing, inspection of all major hazard events that may occur due to poor catchment protection, poor condition and operation of tubewell, poor ART operation and maintenance, and poor hygienic practices by caretakers, and end-users	Source: during tubewell selection and annually on a random selection of tubewells throughout the deployment area ARTs: semi-annual sampling on the random selection (5%) of SIDKO units that are analysed for microbial water quality	NGO or ART provider, in coordination with DPHE	Data stored at local levels and transferred to national water supply information centre (in the interim, all data should be submitted to NAMIC)
Testing of chemical water quality	Phosphate, manganese, nitrate and iron analyses using field test kits (Hach or equivalent) on 5% of the tubewells and ARTs, with a minimum of 5% samples also submitted to analytical labs for confirmation	Source: during tubewell selection, and in response to complaints ARTs: semi-annual sampling on the random selection (5%) of SIDKO units throughout the deployment areas, in conjunction with the microbial sampling	NGO or ART provider, in coordination with DPHE	Data stored at local levels and transferred to national water supply information centre (in the interim, all data should be submitted to NAMIC)
Survey of physical water quality	Survey of aesthetic and physical water quality parameters - smell, turbidity, colour, taste, etc.	Source: during tubewell selection, and in response to complaints ARTs: on installation and in response to either complaints or the results of the semi-annual survey	NGO or ART provider, in coordination with DPHE	Data stored at local levels and transferred to national water supply information centre (in the interim, all data should be submitted to NAMIC)
Inspection of waste management practices	Survey caretakers to ensure proponent collected wastes as per verification certificate responsibilities Proponents to produce annual reports of waste management practices	ARTs: conducted during the semi-annual visits to SIDKO ARTs	NGO or ART provider, in coordination with DPHE Annual reports produced by proponents and available for NGOs and Government of Bangladesh as required	Information to be maintained by NGO or ART provider (the local level), and supplied to relevant Government of Bangladesh (the national level)

Note: The verification tasks identified in Table 8 are the joint responsibility of NGOs and other organisations providing the ARTs, and DPHE. Therefore, coordination between the ART providers and DPHE is necessary to gather the information necessary to continually verify the different components of the WSP.

Table 9. Validation schedule.

Process Step	Hazardous Event	Validation
All processes	Introduction of pathogens and presence of arsenic and other pollutants	Use of verification data in quantitative health risk assessment model to assess changes in potential disease burden
Social inclusion	Members of community have no/restricted access to water source	Community meetings demonstrate that access is assured to all
Catchment	Introduction of pathogens and nitrate via hazardous events identified in Table 6.	Combined analysis of water quality and sanitary inspection data from verification to assess whether protection measures have been effective
Source tubewell	Introduction of pathogens into well via hazardous events identified in Table 6. ART is not appropriate for the tubewell water quality, as discussed in Table 6.	Combined analysis of water quality and sanitary inspection data from verification to assess whether protection measures have been effective Analysis of well inspection data and tubewell water analyses from verification, and comparison to SIDKO deployment conditions outlined in the Verification Certificate to assess whether source well selection measures have been effective and the tubewell water contains water with concentrations of arsenic, iron and phosphate that are suitable for a SIDKO ART, and is otherwise safe (for manganese, boron, etc.)
Centrifugal and hand pump	Introduction of pathogens at pump via hazardous events identified in Table 6.	Combined analysis of water quality and sanitary inspection data from verification to assess whether protection measures have been effective
ART treatment	Poor operation and maintenance of the ART, leading to unsafe concentrations of arsenic and other chemical and microbial contaminants, and poor aesthetic quality of treated water via hazardous events identified in Table 6.	ART Verification Certificates confirm that the SIDKO ARTs consistently produce arsenic-safe water, when operated and maintained according to the proponents' protocols, at tubewells with appropriate water quality Review of O&M records and practices, analytical results of treated water samples, ART tank and pipe inspection data, and sanitary inspection data from verification to assess whether O&M and hygiene training have been effective
Post source	Introduction of microbial pathogens due to unsanitary practices during collection, transport and storage of water, as discussed in Table 6.	Analysis of water quality data and results of sanitary inspection data from verification to assess whether hygiene education has been effective
Waste Management	Inappropriate disposal of ART wastes	Review waste management records to ensure proper disposal practices are followed

Note: The validation tasks identified in Table 9 are the joint responsibility of NGOs and other organisations providing the ARTs, and DPHE. Therefore, coordination between the ART providers and DPHE is necessary to gather the information necessary to continually validate the different components of the WSP.

Table 10. Improvement action plan.

Issue Identified		Action Required	Procedures or Records?	Responsibility	Time Frame	Status
No.	Issue					
1	Social exclusion and proper site selection	Discussions with community to develop an ART deployment guideline that deals with social integrity, equal access, cross-subsidies and other mechanisms to ensure that the poor are not excluded from access to safe drinking water from ARTs Site selection practices discussed in consultation with the local WATSAN committee, community committee, etc.	Follow the ART deployment guideline	NGO or organisation providing ART, in coordination with DPHE	Short - Long	
2	Sanitary protection in the catchment	Establish minimum safe distances for latrines, animal pens and waste dumps	Follow guidelines from DPHE, or 10m as a default	NGO or organisation providing ART, in coordination with DPHE	Short	
3	Source water quality	Inspect the tubewell to ensure that it is in compliance with the requirements of the WSP for tubewells, collect analytical samples of the tubewell water to confirm that it complies with WHO drinking water quality guidelines, and review the data for key water quality parameters to ensure that the tubewell is appropriate for the SIDKO ART	Follow tubewell WSP requirements, WHO drinking water quality guidelines, and deployment conditions in the SIDKO ART Verification Certificate	NGO or organisation providing ART, in coordination with DPHE	Short - Long	
4	Maintenance of well	Training of caretakers and provision of notes and tools for basic sanitary maintenance	Follow standard training and develop minimum community maintenance pack	NGO or organisation providing ART, in coordination with DPHE	Short	
5	Centrifugal and hand pump design and maintenance	Pump must be firmly attached to platform and platform should be at least 1 m in diameter. There should be proper drainage around pump Safe water should be used to prime pumps	Follow approved standard designs Follow best practices	NGO or organisation providing ART, in coordination with DPHE NGO or organisation providing ART, in coordination with DPHE	Short Medium	
6	Safe operation and maintenance of ARTs	Caretakers are provided with O&M manual, spare parts and tools, and given adequate training to ensure that the ART is inspected, operated and maintained properly	Follow the requirements of the O&M manual that is provided by SIDKO	NGO or organisation providing ART, in coordination with DPHE	Short - Long	

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Issue Identified		Action Required	Procedures or Records?	Responsibility	Time Frame	Status
No.	Issue					
7	Ensure safe water handling post source	Develop guidelines and provide hygiene and sanitation education program to community/end-users to ensure safe water handling during collection, transport and storage – the program should include follow-up visits	Follow guidelines for hygiene and sanitation	VBO members and NGOs responsible for undertaking hygiene education programme	Short - Long	
8	Ensure safe disposal of wastes	Manage wastes as per the GoB requirements	Follow standard procedure for management of wastes for a technology	ART proponent	Long	