Report of the Central Team on Arsenic mitigation in rural drinking water sources in Ballia district, Uttar Pradesh State

14-17 September 2011

Ministry of Drinking Water and Sanitation

Government of India

New Delhi

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1.0 Background and Central Team composition

There had been several newspaper clippings indicating that arsenic contamination in drinking water sources in Ballia district of Uttar Pradesh is creating hardship to the local people and several people are suffering from arsenecosis disease. Also, the capacity of the medical doctors is inadequate to diagnose arsenecosis and prescribe preventive medicine. This issue was brought out to the Ministry by an active NGO called "Inner Voice Foundation" headed by a dynamic person called Saurabh Singh. After interactions of the Ministry at various levels with Mr Singh, it was decided to study the problem in its totality and suggest the State Government about a clear roadmap for surveillance of arsenic related problems and provide arsenic free drinking water to the population of Ballia district, apart from providing similar interventions in other arsenic affected areas in the State of Uttar Pradesh.

The Ministry then deputed Shri Radha Charan Dixit, a National Level Monitor (NLM), who was retired Scientist & Head, NEERI, zonal laboratory Delhi. The NLM visited Ballia district in June 2011 and submitted his report which indicated inadequacy of O&M and availability of arsenic-free drinking water and hospitals without well-trained medical doctors who cannot diagnose the disease properly and provide medical and nutritional interventions. However, the report of the NLM was found more general in nature and did not cover the situation holistically. Further, the report did not provide adequate measures to counter the situation and indicate a road map for tackling arsenic related problems.

Consequently, the Ministry decided to send a Central Team with members having expertise in various fields. The composition of the Team was as below:

1) D.Rajasekhar, Deputy Adviser(WQ), Ministry of Drinking Water and Sanitation, GOI, New Delhi
2) Dr. T.Krishna Gopal, Sr. Scientist, Indian Institute of Toxicological Research, Lucknow
3) Dr. K.B.Biswas, Regional Director, Central Ground Water Board, Lucknow

4) Dr. G.Khadse, Sr. Scientist, National Environmental Engineering Research Institute, Nagpur
5) Shri Amit Mehrotra, Project Officer, Unicef, Lucknow
6) Shri S.M.Sharma, Consultant(Hydro-geology), NRC, MDWS

The Team was also associated with Shri Saurabh Singh, M/s Inner Voice Foundation, Ballia, Mr. Satyaprakash Kureel, Chief Engineer, UP Jal Nigam, Mr.R.M. Tripathi, Jt. Director, U.P. Jal Nigam, Mr. Srivastava, Executive Engineer, Ballia, U.P. Jal Nigam, Dr DS Pandey, Scientist -D and Sri Prashant Rai, Scientist-C from CGWB, Lucknow, Mr K.J.Rajeev, Regional Manager, WaterAid, Mr. Anand Singh, Project Coordinator, Purvanchal Gramin Chetna Samiti and the State level chemist from UPJN along with water quality testing lab staff.

The Team conducted field visits in Ballia district during 14-15 September 2011 and held debriefing meeting with Executive Director and Special Secretary, Govt. of Uttar Pradesh, Lucknow on 16th September 2011.

2.0 Salient features of Ballia district

Basic Information			
Geographical Area :	2981.00 Sq. Km.	No. of Blocks:	17
Basin	Ganga	Population	2752000
Availability of Ground Water :	114713 ham.	Stage of G.W. development:	45.33%

Ballia is the eastern most district of Uttar Pradesh covering an area of 2981 sq.km, lies in between 25°33' and 26 °11' North latitudes and 83° 38' and 84° 39' East longitudes with total population of 2752000 as per 2001 census (density of 925/sq.km). The district is bounded on north by Ghagra river and in south by Chhoti Sargu and Ganga river. The entire district forms an interfluves zone of Ghagra & Ganga river and possesses plain flat topography. The irrigation in the district takes place by Dharighat Lift Irrigation canal and Tubewells. The average rainfall of the district is 983 mm with 41.5° C highest and 5.4° C minimum average normal temperature.

The irrigation in the district is done both by pump canals and tubewells. The share of surface water irrigation is 27.39% while that of ground water is 72.61%. The district is drained by Ghagra, Chhoti Saraju and Ganga rivers. Ghagra has shifted its course very frequently. There are number of lakes and ponds like Surha Tal, Mundvi Shah in between Maniyear & Bawdeeh, Reoti Tal & Sikandarpur Tal etc. Besides this there are number of abandoned channels in form of Tals and Ponds.

3.0 Geo-morphology and Hydro-geology of Ballia district

Geomorphology

Ballia district falls in Central Ganga plain. General topography is flat to gentle undulation. Following geomorphic units have been demarcated in the district. (Please see Map-1)

a) Flood Plain:

It is restricted all along the river channels. The area is mostly covered by present river and its adjacent smooth plains. It is comprised of coarse to fine sand, silt, clay and gravel. The sand bar, abandoned channels levies landforms are very common in the area.

b) Newer Alluvial Plain:

It refers to old flood plain cycle of deposition. It is mostly consists of unconsolidated coarse to fine sand, silt and clay of varying amounts. The fluvial landforms, like paleo-channels meander scar, back swamps etc. are observed.

c) Older Alluvial Plain:

The older alluvial plain forms the central part of the Ganga-Ghaghra interfluves. The surface water divide passes through the area. The area is flat and gently undulating due to paleochannels. It gently slopes towards east besides north and south of water divide. It is mainly constituted of coarse to fine sand, silt and clay. Paleo-channels meander lakes marshy and swampy lands are very common in this unit.

Soil Characteristics:

Soil of Ballia district is loamy in nature. It can be further classified on the basis of texture, colour, pH and drainage. Four type of Land capability classification are grouped on basis of soil.

(a) Good Cultivable Land:

This is the area of younger and older alluvium. Colour of soil is light grey, yellowish brown, pH of soil varies from 7.8 to 8.3. It is well drained slightly eroded soil. It covers area from east to west and north to south. Major parts of the district occupy this type of soil.

(b) Moderately Good Cultivable Land:

Soil of this area is same as first group but due to moderately erosion its fertility has decreased, pH of this group of soil varies from 7.2 to 8.2. Its texture varies from silty to clayey loam.

(c) Fairly Good Land (Occasional Cultivation):

This soil has moderate to imperfect drainage, pH varies from 7.8 to 9.2. This type of soil is found in canal command area and around lakes and ponds. Due to shallow water table all salts are deposited near the surface of soil. Hence, pH of soil increased.

(d) Non Cultivable Land:

Texture of soil is brown loam, clayey in nature. Due to capillary action salts are deposited near surface, pH of soil is 9.5 to 10.3. It is poorly drained soil, not suitable for

cultivation. This type of soil is found south of Rasra and north of Chhoti Sarju River. It occurs in patches.

Hydrogeology

The area is underlain by Quaternary alluvium consisting of days, sand and gravels. The sandy horizons form the aquifer zones. (Please see map-2)

Based on exploratory borehole data of Central Ground Water Board and tubewells data of State Government the following aquifer zones have been identified.

S.N.	Aquifer	Western Part (Depth Range in meters)	Eastern Part (Depth Range in meters)
1.	Ist	40.0-100.0	Down to 90.0
2.	IInd	365.0- 457.0	100.0- 160.0
3.	IIIrd	515.0- 540.0	180.0- 340.0

Ground water occurs under unconfined to semi-confined to confined conditions.

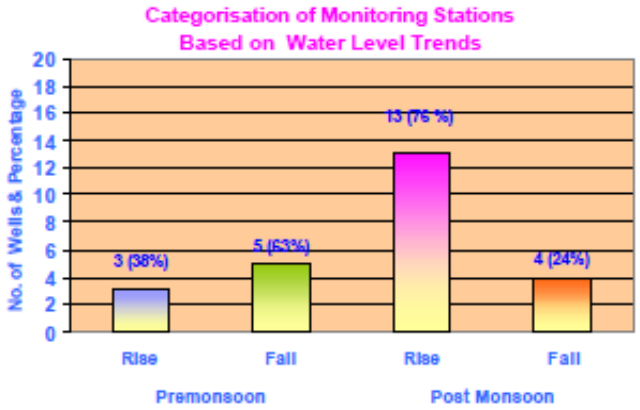
Depth to Water Level:

As per depth to water level data of ground water monitoring stations of year 2006 pre-monsoon water level varies from 2.42 to 9.90 mbgl. In post-monsoon period depth to water varies from 1.55 to 8.35 mbgl. Water level fluctuation varies from 0.85 to 3.65 meters. Shallow water level is in Cannal command area. Water level is deeper in bank of Ganga and Ghaghra.

Long Term Water Level Trend :

The long term water table trend analysis indicate that in some of the blocks of the of the district like Reoti Maniya, Siyar, Beruarbari, Shoaon, Mubli chhapara,l Hanumanganj, Belhari and Bariya hydrograph stations have declining trend while other rest of the hydrograph stations have rising trend either due to accrual seepage or due to irrigational seepage.

Fig- 1 Monitoring stations



Ground water quality

The mineralization of ground water depends upon lithology, texture and nature of soil and hydrogeological property of zone through which water moves. The water samples collected from ground water monitoring wells are analysed in Chemical laboratory, Central Ground Water Board, Northern Region, Lucknow. The major constituents except Arsenic are within permissible limits as per drinking water norms. The Electrical conductivity on an average is between 500 to 1000 microsimen/cm. **The quality of ground water in deeper aquifer is comparatively better than that of phreatic aquifer. The value of sodium adsorption ratio (SAR) at Bansdih, Khureji and Garwar villages is found to be above permissible limits for irrigation**.

In arsenic affected area, CGWB has conducted a detailed sampling and analysis of groundwater in Belehari and Bairia blocks. Total 72 numbers of samples collected from dug wells, private hand pumps and India mark II hand pumps have been analyzed in Chemical laboratory of Central Ground Water Board, NR, Lucknow.

- The depth of these ground water abstraction structures varies from 13.0 to 64.0 meters.
- **The arsenic value varies from 2.0 to 1310 ppb.**
- **The value of arsenic has been above 50 ppb in 52 samples.**

To mitigate the arsenic problem, a few exploratory tube wells have been constructed by CGWB in arsenic affected blocks.

Concentration of Arsenic in the First Aquifer system : As per results of ground water exploration carried out in the arsenic affected blocks concentration of arsenic in first aquifer system (down to 90.0 meters) have been found 3.3 ppb at Ramgarh, 5 ppb at, Dalanchhapra and 25 ppb at Rajpur Ekauna.

Concentration of Arsenic in the Second Aquifer system : In second aquifer system (depth range 100 to 180 meters) arsenic concentration have been found 1.1 ppb at Ramgarh, 25 ppb at Rajpur Ekauna and 25 ppb at Dalanchhapra .

Concentration of Arsenic in the Third Aquifer system : In third aquifer system (depth range 180 to 340 meters) concentration of arsenic have been found 3.3 ppb at Ramgarh, 5 ppb at Gaighat and 25 ppb at Dalanchhapra. The concentration of fluoride is within permissible limit as per CGWB in the third Aquifer.

Groundwater Abstraction for Drinking water Supply

Groundwater abstraction for Drinking water has been achieved through Drinking water tube wells that have been constructed in town area and villages for providing water through pipeline scheme. Depth of drinking water tube wells tapping 12 to 30 m granular zones varies from 77 to 129 mbgl. The yield of tube wells varies from 1000 lpm to 2000 lpm.

Besides pipeline scheme through tubewells, India Mark II Hand pumps have also been constructed for drinking water. Depth of these hand pumps varies from 33-50 m.

Recently, for mitigation of arsenic in ground water India Mark II hand pumps of 70.0 meter depth have been constructed in Arsenic affected blocks.

The stage of ground water development in the district is 70.30%. The maximum stage of ground water development is in Rasra block (89.42 %) and minimum stage is in Murlichhapra block. In four blocks Bairia Garwar, Rasra and Siar the stage of ground water development is above 80 %. The blocks Beruarbari, Sohaon, Chilkhar, Maniar, Nagra, Navanagar falling in cannal command area and have less than 70% stage of ground water development. The parts of Nagra, Pandah and Sohaon are water logged. In non command area only one block Murlichhapra has stage of ground water development less than 70%.

Hence, these blocks have good scope for further ground water development through shallow and moderately deep tubewells. In canal command area strategy of conjunctive use of surface and ground water needs to be adopted for future ground water development.

Surface Water Bodies:

In Ballia district there are number of ponds and lakes. These are natural water conservation structures. As district is in interfluve of Ganga and Ghaghra river with thick sand cover on top, recharge takes place naturally from return flow from irrigation (Dhorighat Cannal system & Surha Tal Cannal Systems) and during flood. As per CGWB reports, the depth to water level at Haldi Bairia Nasirabad and Dalanchhapra has been recorded below 5.0 meter in postmonsoon period. The annual long term water level trend is also declining i.e. Haldi (1.1 cm/year) Nasirabad (8.3 cm/year) Bairia (15 cm/year) and Dalanchhapra (15.8 cm/year). In Bairia and Dalanchhapra magnitude of declining trend is more than 10.0 cm/year. **Hence Artificial Recharge scheme may be taken up in Bairia block to check the declining water level trend.**

Arsenic in Groundwater from different Abstraction Structures:

Arsenic above permissible limit in shallow aquifer is found in parts of Ballia district. It is a geogenic problem Please see map no. 3 . Water samples from India Mark II hand pumps, Private hand pumps and dug wells from Chain Chhapra, Rajpura Ekauna, Chaube Chhapra, Ramgarh Dhala, Reckni Chhapra Dalan Chhapra and Sughan Chhapra village have arsenic concentration more than 10 ppb. These all villages are located in flood plains and younger alluvium. Depth of abstraction structure varies from 13 to 64 mbgl. Due to excess of Arsenic in ground water people are reported to be suffering from diseases like skin cancer, ulcer and pigmentation in skin and hardening in palm skin. To mitigate arsenic problem, Jal Nigam, with the help of UNICEF have analysed all hand pumps in the district by Arsenic kit.

Central Ground Water Board, Northern Region has started exploration study in Arsenic affected blocks of Ballia district in April, 2005. Till March 2007 in five blocks i.e. Belehari, Bairia, Murli Chhapra, Reoti, Maniar deep exploratory tubewell have been constructed for providing safe water in arsenic affected villages.

4.0 Chronological events of Arsenic mitigation in Uttar Pradesh State and support of Unicef

Understanding Arsenic

Arsenic is a ubiquitous element, ranking 20th in element abundance in earth's crust. Elemental arsenic ordinarily occurs in two allotropic forms, yellow and steel grey metal like mineral. Arsenic is also found occurring with ore of gold, copper and iron and primarily associated with igneous and sedimentary rocks in the form of inorganic arsenic. When arsenic combines with oxygen, chlorine, sodium and sulphur, etc., it is termed as "inorganic arsenic" and when combines with carbon and hydrogen, it forms "organic arsenic". It is important to note that organic forms of arsenic are usually less dangerous than inorganic arsenic. Apart from geogenic reasons, arsenic contamination could be found due to anthropogenic reasons like mining, copper smelting, waste-water dumping of sewage sludge, thermal power plants, manufacturing processes, urban runoff and atmospheric deposition.

Arsenic contamination in drinking water causes a disease called arsenecosis. Symptoms of arsenecosis are primarily manifested in the forms of different types of skin disorder such as skin-lesions, hyper-keratosis and melanosis. Prolonged consumption of arsenic rich water may be carcinogenic.

Skin pigmentation due to Arsenicosis

Initially, Jadhavpur University came out with a report on Arsenic contamination in drinking water sources in Ballia and Lakhimpur in 2005. The study was supported by UNICEF. The Arsenic Testing Methodology adopted was as below:-

- After getting this report UP Jal Nigam (UPJN) performed testing in all habitations of Ballia and Lakhimpur using a) screening and b) blanket method.
    - Screening - In those habitations where there were < 10 public sources one was tested and in those > 10 two sources were tested.
    - Blanket- In those blocks with > 10% sources with > 50 ppb all public sources were tested. In case blocks had < 10% affected sources but habitation had > 10% affected sources, blanket test was performed on all sources in that habitation.

Arsenic Testing in Phase I and Phase II

- From the analysis it was realized that Arsenic is geo-genic in nature and is found in younger alluvium. On the basis of this 289 blocks of 49 additional districts were identified which are along river Ganga and Ghagra and Arsenic testing was performed in 2006 for about 110,000 sources.

- In the identified blocks of 49 districts screening/ blanket tests were performed as per above methodology i.e. screening and blanket testing.
- The test results showed that Arsenic above 50 ppb (limit set as safe by Department of Drinking Water, GoI) was found in 18 districts and Arsenic in the range of 10 (limit set by WHO)-50 ppb was discovered in 31 districts (including 18)

Arsenic Testing in Phase III

- In 2007 and 2008 blanket testing was performed in about 40,000 sources five districts i.e. Bahraich, Gorakhpur, Ghazipur, Chandauli and Bareilly, where > 50 ppb Arsenic concentration was higher as compared to other districts.

Test Results

- As of now, testing of about 1.1 lakh sources has been completed which has shown that As above 50 ppb is found in 2,610 habitations of 20 districts with another 10,434 affected sources recording Arsenic concentration between 10 and 50 ppb. District-wise details is tabulated below:-

Results of testing of arsenic in groundwater in 51 districts of Uttar Pradesh

Sl..	District	Blocks	HPs tested	Upto 10 ppb	10 - 40 ppb	40- 50 ppb	Above 50 ppb
1	Saharanpur	4	661	2	0	0	0
2	Muzaffarnagar	6	684	0	0	0	0
3	Meerut	2	208	0	0	0	1
4	Baghpat	4	344	0	3	0	0
5	Ghaziabad	2	165	0	0	0	0
6	G B Nagar	3	462	0	0	0	0
7	Bulandshahr	4	558	0	0	0	0
8	Moradabad	4	654	95	84	11	8
9	Bijnor	7	1917	209	248	7	3
10	J P Nagar	4	760	0	0	0	0
11	Rampur	4	1112	0	0	0	0
12	Aligarh	3	596	0	0	0	0
13	Mathura	8	1500	0	0	0	0
14	Etah	3	723	0	0	0	0
15	Budaun	11	1890	6	2	0	0
16	Bareilly	9	1571	171	224	14	22
17	Pilibhit	7	1647	112	55	0	0
18	Shahjahanpur	9	1193	76	147	12	3
19	Sitapur	7	3831	3660	170	1	0
20	Hardoi	10	3273	0	0	0	0
21	Lucknow	5	1558	0	0	0	0
22	Unnao	10	2681	0	23	4	11
23	Rae Bareli	10	4477	1	1	0	1
24	Barabanki	8	1700	81	72	0	0
25	Faizabad	5	2444	55	47	7	0
26	Ambedkar Nagar	4	2330	15	12	0	0

27	Sultanpur	11	4007	100	0	0	0
28	Kanpur Nagar	2	431	0	1	1	0
29	Farrukhabad	5	1726	0	0	0	0
30	Kannauj	3	1245	0	0	0	0
31	Bahraich	10	6509	769	1530	729	766
32	Gonda	9	7071	120	142	15	4
33	Balrampur	7	2108	605	79	1	1
34	Siddharth Nagar	7	1899	79	133	18	16
35	Basti	6	3104	376	215	17	12
36	St Kabir Nagar	1	292	0	46	2	7
37	Maharajganj	1	199	0	0	0	0
38	Gorakhpur	11	4218	121	230	31	50
39	Deoria	7	1426	0	0	0	0
40	Mau	3	1509	0	0	0	0
41	Fatehpur	5	1682	0	0	0	0
42	Allahabad	13	2140	0	0	0	0
43	Kaushambi	6	1415	1415	0	0	0
44	Pratapgarh	2	1490	0	0	0	0
45	Varanasi	5	1309	0	0	0	0
46	Chandauli	4	1460	19	13	4	12
47	Ghazipur	9	3923	1115	171	43	52
48	S R Nagar	2	1198	4	10	1	7
49	Mirzapur	8	3595	23	60	40	3
	Total	**290**	**92895**	**9229**	**3718**	**958**	**979**
50	Ballia	15	10151	6255	2299	476	1121
51	Kheri	17	8442	4949	2730	253	510
	Total	**32**	**18593**	**11204**	**5029**	**729**	**1631**
	G. Total	**322**	**111488**	**20433**	**8747**	**1687**	**2610**

Districts with drinking water sources with >50ppb Arsenic conent

Sl. No.	District	No of Total HPs tested	Above 50 ppb
(A)	**Phase-I Districts**		
1	Ballia	10151	1121
2	Kheri	8442	510
	Total	**18593**	**1631**
(B)	**Phase-II District**		
1	GHAZIPUR	3923	52
2	CHANDAULI	1460	12
3	SANT RAVIDAS NAGAR	1198	7
4	MIRZAPUR	3595	3
5	MORADABAD	654	8

6	BIJNOR	1917	3
7	MEERUT	208	1
8	BAHRAICH	6509	766
9	GORAKHPUR	4218	50
10	SIDDHARTH NAGAR	1899	16
11	BASTI	3104	12
12	SANT KABEER NAGAR	292	7
13	GONDA	7071	4
14	BALRAMPUR	2108	1
15	BAREILLY	1571	22
16	UNNAO	2681	11
17	SHAHJAHANPUR	1193	3
18	RAE BARELI	4477	1
	Total	**48078**	**979**
	G. Total	**111488**	**2610**

Mitigation Strategy and Efforts made by Government of UP so far::

- For providing safe water to the communities the initial strategy adopted in 2006 and 2007 was to install deep tube wells whereby 475 affected habitations of Ballia and Lakhimpur have been provided with Hand Pumps on deep tube wells.
- In 2008, Secretary (DWS), Government of India took a decision not to puncture arsenic affected aquifer and stop deep tube well approach.
- Then the alternative mitigation strategies left were – a) providing surface water source by lifting water from rivers such as Ganga and Ghagra, which is highly capital intensive and long term mitigation measure, b) use shallow wells as sanitary wells for providing arsenic safe water, which also is not a safe source as discovered by recent testing in Bahraich, c) install community based filters and provide home based filters with proper community orientation for arranging back washing and proper disposal of filtered arsenic which is highly concentrated in nature, d) community awareness.
- While a mitigation plan was made and approved by U.P. Jal Nigam for providing safe water in 492 habitations using option (b) above, but with the recent threat of occurrence of arsenic in shallow aquifers, has put a halt on mitigation measure using this approach.
- In order to tackle effect of arsenic on Health, UNICEF entered into a partnership with K.G.Medical University and developed a technical manual for the health professionals.
- Using this health manual training was organized for all MOICs of Ballia in early 2008.

- In the meantime UNICEF has supported a pilot project for providing community based filters (a technique which is commonly used in West Bengal and even in Bangladesh) at seven locations in Lakhimpur, Bahraich, Gorakhpur and Ballia districts, out of which four units are now functional. UNICEF also kept on advocating efficacy of this approach in the absence of alternate mitigation measure. Based on the utility of this approach, the Government of U.P. has approved a budget for installing 310 such community based filters in arsenic affected habitations, which have been installed in Ballia. In Gorakhpur, Bahraich and Lakhimpur also, 500 similar filters have been installed.

Arsenic Removal Plant
(Activated alumina based)

The summary of various arsenic mitigation works taken up and reported by UP Jal Nigam in various districts are :

<u>District-Ballia</u>: For 310 habitations of district following measures have been taken

- 103 habitations have been covered by installing 498 Extra Deep India Mark-II HPs.
- 81 Habitations has been provided with safe water through 20 PWS.
- 37 piped water supply scheme covering 117 Arsenic Affected habitations of district Ballia amounting are under construction.
- Remaining 9 habitations are proposed to be covered by installation of extra-deep hand pumps.

Deep Tube-well based
Piped water supply

<u>District-Lakhimpur Kheri</u>: For 165 habitations of district following measures have been taken

- 57 habitations have been provided with safe water through 135 extra deep hand pumps.

- 103 Arsenic Affected habitations of district Lakhimpur Kheri have been provided with safe water supply through 21 piped water supply schemes.
- Remaining 5 habitations are being covered under another PWS. This village will be covered by March 2012..

District-Gorakhpur:

All the 45 habitations in Gorakhpur have been provided with safe water by installing Arsenic Removal Units.

District- Bareilly:

All the 17 habitations in Bareilly have been provided with safe water by installing Arsenic Removal Units.

District- Chandauli:

18 habitations have been provided with safe water through PWS/ Extra Deep HPs. Remaining 1 habitation will be provided with Piped Water Supply by 12/2011.

District- Ghazipur

20 habitations have been provided with safe water through PWS/ Extra Deep HPs. Remaining 4 habitations will be provided with Piped Water Supply by 12/2011.

5.0 Interventions by M/s Water Aid India in Ballia district

WAI on the basis of analysis of various study reports and community situation stated working with the community on arsenic mitigation as the problem of Arsenic has been widely analyzed and reported but none has worked on mitigation in Ballia at community level. WAI organized an exposure visit for the community representatives in Dec 09 to" Water for People", Kolkata who have being able to provide Arsenic free water to communities through community filters which are operated and maintained by communities themselves. This filter has been designed by BESU and has been quite successful in West Bengal with recharge centers being established for regeneration and residue management.

WAI and the its local partner DOV installed three community filters in the first phase to provide communities with Arsenic free water and to demonstrate to sector institutions and departments how communities can operate and maintain community filters with appropriate capacity building.

WAI when decided to implement the programme all key stakeholders were involved who were: Uttar Pradesh Jal Nigam, Department of Rural Development, District Magistrate, DOV, WAI and BESU.

Community filters can cater to a large number of people in a community with safe water and is a interim solution to water quality affected areas like Arsenic affected habitations. With community ownership and management structure, the community filters can be successfully implemented. An example of one such filter was set up in

West Bengal by **'Water for People',** an organization working in India since 1998. The organization, in a joint collaboration with Bengal Engineering and Science University (BESU), developed a simple Arsenic Removal Filter(AMAL). The best feature of the filter was that it was managed, operated and maintained by the community. The organizations only facilitated and supervised the system to make it completely community-run.

The salient features of the community filter were....

- The filter can be locally produced, hence affordable.
- It requires no electricity for its operations
- The maintenance of this filter is easy as it requires servicing every 8-12 months.
- It can provide safe drinking water to at least 300 families and 1,500 school children.
- The life of this filter is 10-15 years. It is strong and looks good.
- Its technology is simple which makes it easier for even illiterates to operate.
- The only careful handling it requires is the safe disposal of its toxic wastes.
- Materials to be used in it, like sorbents, can be procured from indigenous sources.

WAI ensured the operation and management of filters by the communities by their capacity building and thus present a model of decentralized monitoring and management of filters, before the key stakeholders such as Uttar Pradesh Jal Nigam, Department of Rural Development, District Magistrate, DOV, BESU and the communities in the project. The initial response was good towards the filters and WaterAid/ DOV called on the Minister of Rural Development, Shri. Daddu Prasad and appraised of the situation of Arsenic in Ballia, WAI's intervention for mitigation planning and the decentralized approach towards operation and maintenance. The Minister having being convinced of the success and impact of decentralized approach, during its inauguration on Sep 14th 2009, announced that the Government will install filters in all the affected 310 villages in Ballia district. UPJN has done the site selection of these 310 filters and within a span of eight months, all 310 filters installed in these villages.

The Decentralized Model of O & M of Arsenic filters:

The decentralized operation and maintenance model of Arsenic filters is based on the following principle:

- Community ownership
- Demand generation including Awareness on Arsenic
- User pay for use of water
- Community responsible for management of filter including O & M through formation of Water Management Committee
- Capacity building of local communities
- Linkages with key sector departments

These principles are explained in detail below:

- Community ownership

- When the programme was initiated in the 3 villages, the communities were involved from the planning process. SHGs and Water Management Committees were formed and they were involved in site selection for installation of filters. The communities visited many water sources along with DOV and technical team and a site was selected based on the parameters of location, distance, technical feasibility and also owner's acceptance.
- The communities took decisions on user fees, quantity of water per day, selection and payment to operator, timing of opening of filter and other decisions regarding management of filter

- Demand generation including Awareness on Arsenic
  - Any hardware will be successful unless demand generation is created. In this project focus was more on demand generation and this was done through awareness. This was done through lane visits, School Arsenic education, Arsenic awareness during SHG and Water management committee meetings, Rallies, Nukkads and through demonstrations
  - The SHG and the Management committee were responsible for demand generation for use of filters

- User pay for use of water
  - Water is not for free and users have to pay for O & M
  - The principle of use and pay is apart from ownership, the Water management committee have to pay operator, charges for repair and maintenance, change of filter media and other unforeseen expenses like change of GI pipes of the hand pump

- Community responsible for management of filter including O & M through formation of Water Management Committee
  - The communities will form a Water Management Committee for management of the filters installed and hence SHGs and the other communities together identified the members and formed the committee

Discussions of the Central Team With the Women SHG managing O&M of Arsenic removal plant

- The committee will have 50% members as women, representatives from the GP
- The committee has their own bank account
- The committee selects a operator who is responsible for daily backwash, informing the water management committee in case of repairs and also opening the filter at the appointed time
- The committee meets once in a month and review the performance of the filter, collection made, payments and also discusses on no of users
- The committee maintains the following registers:
  - Complaint book
  - Water quality register
  - Back wash register
  - Minutes book
  - Contribution book
  - Bank pass book
  - Apart from this there is a suggestion box, a board informing of last water quality testing done, other water quality parameters, timing of opening of filter and methodology of back wash

- Capacity building of local communities
  - The project trains SHG members, Water management committee members on Arsenic, O & M.

- Linkages with key sector departments
  - The project works closely with UPJN, BESU, Min of Rural Development, ITRC, SATHEE for technical guidance, water quality testing and convergence with other programmes like NREGS

Jal Surakshaks for Decentralized Model of O & M of Arsenic filters at district level:

After installation of filters the communities were unaware of the O & M requirements as they were not trained on the same. A rapid survey was commissioned to see the functioning of filters and a total of around 230 filters were surveyed saw that 77% of the functional filters were used and 23% of the filters were not used and in 90% of the filters, people in the community were unaware of backwash and was taking water from the filter without doing backwash. **Thus the project identified 2 volunteers from each of the villages were the filters were installed and trained as Jal Surakshaks and totally around 620 persons were trained.**

As per the guidelines of NRDWP , WAI provided capacity building of identified volunteers as Jal surakshaks on O & M, Sanitary survey and water quality monitoring and basics of water security plans. As in the first phase these people were given a two day course on the following:

- Water – Availability of water, Quality of water
- Arsenic – What it is, Arsenic in India, Arsenic in Ballia, The story of Arsenic in Ballia (already shared with the team)
- Arsenic from various sources
- Arsenic a recent or ancient phenomenon – Discussion
- Arsenic in shallow and deep aquifers
- Manifestation of effects of Arsenic
- Arsenicosis and its various stages
- Arsenic mitigation measures
    - Various options and its strength and weakness (RWHS, Sanitary well, Filters – community and domestic)
    - Filters as a measure
- Assessment of existing water sources in the participants villages (Piped water supply and discussion on its source and Arsenic, Deep borewell, Shallow borewell)
- Government schemes for Arsenic mitigation
- Government schemes for O & M, Opportunities under water security plan
- Community filters for Arsenic mitigation
- Decentralized approach for O & M of filters
- Water management committee and its roles and responsibilities
- O & M of community Arsenic filters – How and practical session
- Water quality testing
- Documentation for Arsenic filters
- Community participation

At present all these trained Jal Surakshaks are involved in the following activities on voluntary basis :

- Backwash of filter with at least a min of twice in a week
- Awareness to communities on Arsenic
- Increasing the users of Arsenic filter
- Reviving VWSC

There is a need to provide some incentives to these Jalsurakshaks so that their motivational levels remain and the plants are run smoothly.

6.0 Methodology adopted by the Central Team for Review

The following methodology was adopted by the Central Team before, during and after the field visits in Ballia district, Uttar Pradesh.

1) Study of report of NLM constituted by the Ministry
2) Interactions with Shri Saurabh Singh, founder of M/s Inner Voice Foundation, reputed NGO working in Ballia district
3) Interactions with Unicef and Water Aid
4) Interactions with CGWB
5) Interactions with officials of UP Jal Nigam
6) Interactions with local people

7) Interactions with District Collector, Ballia district
8) Interactions with Ballia District Hospital authorities
9) Field Observations
10) Random water quality testing and
11) Debriefing meeting with Special Secretary and Executive Director, SWSM, Govt. of UP., Lucknow

7.0 Field Observations

Dalan Chapra village

On 14th September 2011, the Central Team visited Dalan Chapra village in Ballia district. It is informed that the village has 5 habitations and the population (2001 census) is 7,198. It is reported that the hand pumps are yielding water containing excess arsenic and iron. A 350m deep borewell is constructed by UP Jal Nigam and a OHT has been put into place and piped water supply is made available. As informed by CGWB, the second aquifer system is free of arsenic and therefore if a proper capping is made, arsenic free drinking water could be provided to the local people. The local people informed that water is supplied for about 4 hours in a day. It is practice of UP Jal Nigam that a security fee of Rs 500/- is collected from the beneficiaries before giving household connection. Also, the beneficiary is expected to pay Rs 18/- per month as water tariff. As on 14/9/2011, only 38 out of 2,500 households have been given household connections. However, some of the villagers informed that they still prefer to consume drinking water from their hand pumps. Almost every household has their own private shallow hand pump also. Arsenecosis patients were seen in the village (eg., Mr. Neeraj who had developed pigmentation due to keratosis). An Arsenic removal plant (activated alumina based) was installed 2 years back but currently, it is non-fucntional.

Laksmipur-Sawan Chapra water supply scheme

This is an arsenic affected village with concentrations of 100 ppb in drinking water sources from hand pumps, whose water depth varies between 40' to 60'. In this village Water Aid had constructed arsenic removal plant which is being managed by a women self help group. During interactions with the women SHG, it was found that they maintain 5 registers viz., Contribution register, Backwash register, Water quality register, Committee minutes book and Complaints register. An arsenic testing kit was also available with the women SHG. The Village Water and Sanitation Committee was in place which comprised of 15 members. **The Women SHG decided to collect Rs 1 per household per day as water tariff to operate and maintain the arsenic removal plant.** At present only 40-50 household are only contributing out of 100 households existing in the village. Out of the collected amount, 60% is given to Caree taker towards O&M cost of arsenic removal plant (ARP) and the balance 40% funds are deposited in a bank account created by the VWSC. It is reported that distribution network has been laid by UP Jal Nigam but there is no water supply at present. **Another ARP installed by UP Jal Nigam was also seen about 200m away but this was found dysfunctional due to non-maintenance. On the sanitation front, only 20% of the households have toilets in their home. This is an area where substantial improvement is required for raising the quality of life amongst the communities.**

Shahpur and Gangapur GP

This is a village with about 250 households. About 10 ARPs have been installed one year back by UP Jal Nigam. In Gangapur GP, a deep tuebwell has been constructed by UPJN and a OHSR was built to provide piped water supply. The distribution piepleine is reported to be cut by Telephone Department officials, which has to be repaired / re-established by UPJN urgently. 50 households out of 250 households are having household piped water connections. Water supply was reported being supplied for 1 ½ hrs in the morning and 1 hr in the evening, every day. Arsenic affected patients were seen in large numbers (eg., Mr. Chandra Prakash Singh, suffering from acute melanosis). Almost all households have private shallow hand pumps, which are also being used for drinking and cooking purposes. One ARP visited in Shahpur habitation is being maintained by the local people and water for drinking and cooking purposes is taken from the ARP treated water only by about 50 households.

Tiwari tola, Gangapur- Ramgarh water supply scheme

This water supply scheme serves about 7,000 people in the area and covers 3 GPs (12 habitations). A deep tubewell of 230m depth and 12"/8" casing is sunk which is yielding a discharge of 2,100 lpm. A 500 KL OHSR is also constructed by UPJN with a 24m staging. About 85 household connections and 45 stand posts have been provided in this area. Many arsenic affected persons were seen in this village. Water supply is being provided for 2 hours each in the morning and evening, every day. On testing arsenic using field test kit, concentration of 20 ppb was still recorded from such a deep tubewell. Leaching of arsenic from the contaminated first aquifer system could be the reason as the lithology of the area hardly contains adequate clay thickness to provide adequate capping. There is another 350m deep tubewell drilled by CGWB, wherein no arsenic was found by checking with field test kit. Since WHO recommends a maximum concentration of 10 ppb in drinking water, the Team suggested to blend water from tubewell with the existing 230m deep tubewell so that the arsenic concentration in drinking water come within safe limits. **On the water supply connectivity front, there were complaints from local people that distribution network is yet to be done in Bolapur and Natbasti habitations, which may be considered immediately by UPJN.**

Amdani GP

A Water supply scheme has been constructed to serve Amdani and Pandepur GPs with a overall population of about 7,000. The depth of tubewell used as source is 100m. A 300 KL OHSR is also constructed with 12m staging. About 30 stand posts have been provided in Amdani GP to provide arsenic free water. However, household connections are yet to be provided in these villages. The villagers when interacted requested the Team to provide household connections to all and they are willing to pay connection fees and monthly water tariff. **Mr. Madan Mishra, Sarpanch of the GP requested to organize a 2-day Camp so that everyone in the GP will deposit their household connection fees.** There was also a request from the local people to connect the adjoining Malikpura habitation, which may also be considered by UPJN. Hand pump water from shallow water showed presence of excess iron in drinking water sources.

Sonbarsa GP

This GP is not in the list of 310 arsenic affected habitations reported by UPJN and uploaded into the IMIS. However, severe cases of arsenecosis affected people were seen by the Central team. The GP is fairly large with a population of more than 18,000. A water supply scheme covering the GP with 8 habitations was constructed in the year 2009. A 400 KL OHSR was also constructed but water supply through pipelines to households is yet to be started. Only 17 stand posts have been created to provide arsenic free water from a deep tubewell of 130m depth which was reported yielding a discharge of 1,750 lpm. However, this deep tubewell water when tested with arsenic field test kit showed presence of 20 ppb of arsenic. **When informed about connection fees and water tariff, the local people informed the Team that no official from UPJN gave information in this regard and they have requested the Central team to arrange for 2-day Connections Mela, so that all interested people can take household connections**. One of the local people informed the Team that his mother died due to arsenic cancer and therefore he is ready to pay any amount of connection fee as he considers health as a priority.

The GPS co-ordinates of the villages visited by the Central Team were as below:

Sr. No.	Name of the village	GPS co-ordinates
1	Dalan Chhapara	25°43'32.29"N, 84°31' 03.99"E
2	Laxmipur	25°44'20.37"N, 84°28' 25.72"E
3	Ramgarh Shahpur	25°46'52.70"N, 84°24' 10.87"E
4	Gangapur Ramgarh	25°47'09.70"N, 84°23' 57.32"E
5	Pandepur	25°45'34.30"N, 84°06' 13.69"E

Field tests were carried out for Arsenic in some of these locations and the results of these field tests are as given below. During the visit, CGWB. Northern Region, Lucknow analyzed 12 no of water samples from different abstraction structures with the field kit. Result of the analysis is given below.

S.No	Location	Location Detail	Source	Concentration of Arsenic (ppb)
Block Murlichchapra				
1	Dallan Chchapra	From CGWB Tubewell , run by Jal Nigam	Tubewell	0.0
2		Handpump within Jal Nigam campus	Domestic H.P.	0.0
3		Handpump adjacent to Jal Nigam campus	India Mark- II H.P.	0.0
4		Individual Villagers	India Mark- II H.P.	0.0
5		Individual Villagers	India Mark-II H.P.	0.0

6		Individual Villagers	India Mark-II H.P.	0.0
7	Sawan Chchapra	From domestic H.P. with arsenic removal device	Unfiltered water sample	50
8			Filtered water sample with device	0.0
9	Babu Ke Shivpur	H.P. installed at H/O Sh Chandrabhanu Singh	India Mark-II H.P.	25
10		Jal Nigam Tubewell	Tubewell	25
Block Bairia				
11	Ramgarh	CGWBTubewell(334 m)	Tubewell	0.0
12		Jal Nigam Tubewell (91 m)	Tubewell	25

A comprehensive survey of testing 100% drinking water sources has to be taken up by UPJN as arsenic might have leached into many habitations which are yet to be listed into their records.

After completing the field visits, the Team interacted with District Collector, Ballia, wherein the CDO, CMO and DPRO were also present. The CMO has agreed with the team that the district doctors lack capacity neither to detect arsenecosis nor to prescribe proper drug and dietary supplementation. The DC also informed the Team that he had been promoting raised platforms for hand pumps, as all arsenic affected habitations fall in water rich area and the level of sanitation is also poor.

U.P. Jal Nigam is carrying out the tube well construction operations in Ballia District for Rural Drinking water supply. On enquiry about the design of tube wells being constructed in Ballia District for Arsenic contamination prone areas, Jal Nigam engineers informed that they are going up to the second aquifer to get relatively low arsenic concentration in groundwater. However regarding the depth up to which tube wells are constructed, it was informed that the tube wells are constructed upto 100 m.

It is to be noted here that there are very thin aquifers in this region and a number of thin aquifer form a particular "Aquifer System". **To get relatively low concentration of Arsenic it is required to go up to the second aquifer system. Merely going up to second Aquifer will not help in getting low Arsenic concentration groundwater.**

Analyzing the hydro-geological structure of the region it is observed that the second Aquifer system starts from 100 m and persists up to 160 m. It is therefore recommended that a few exploratory tube wells may be constructed up to 160 m with proper sealing arrangements for the fist aquifer system up to 90 m. This way low arsenic concentration water may be obtained from second aquifer system beyond 100m.

8.0 Recommendations of the Central Team

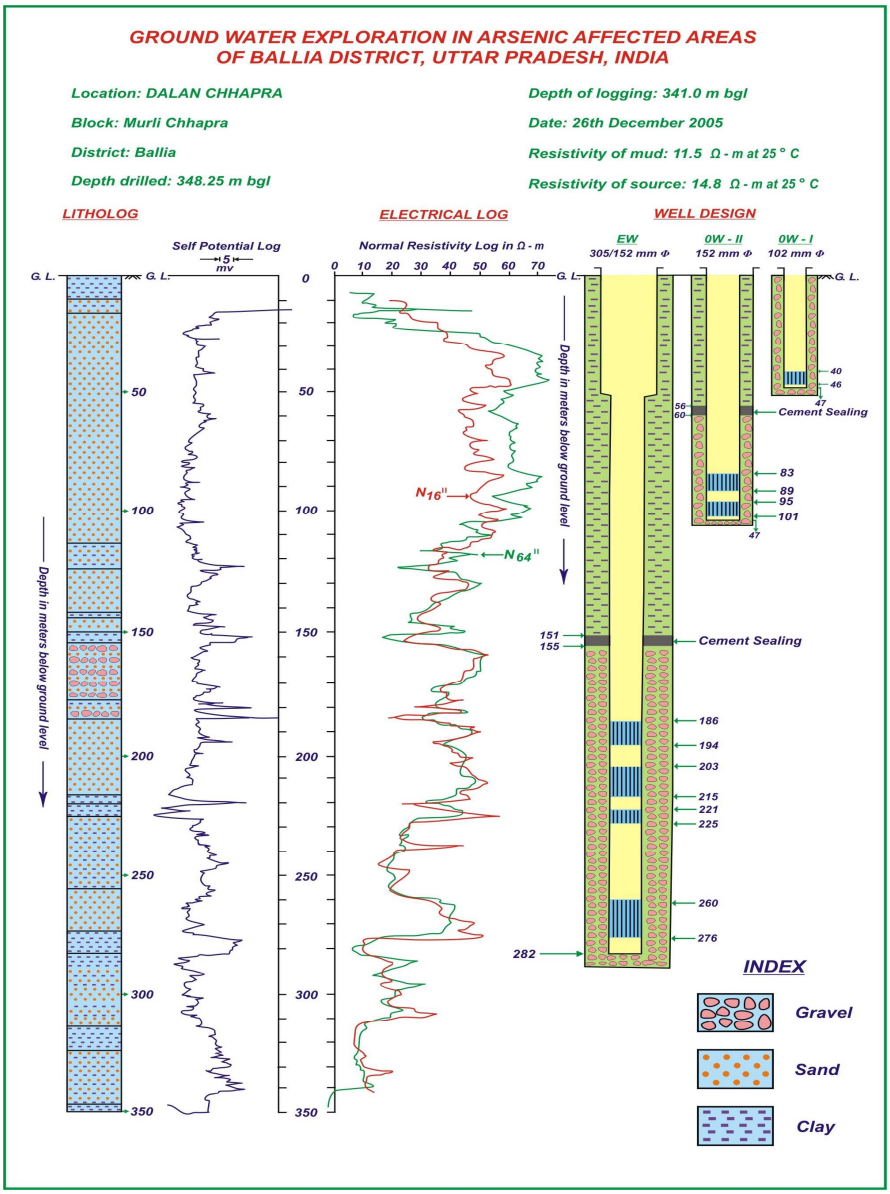
1) The State level Arsenic task force set up in Uttar Pradesh needs to be re-activated immediately.

2) The State level arsenic task force of West Bengal, after examining various technological options, decided that surface water based piped water supply system wherever feasible, is the most appropriate and sustainable solution for arsenic problems in groundwater based drinking water sources. It is surprising to note that hardly there were any surface water based schemes in Ballia district. Both Ganga and Ghagra are perennial rivers and therefore, "**river bank filtration**" **system could be explored as done successfully along Alaknanda river in Uttarakhand by Uttarakhand Jal Sansthan.** This method involves identification of an appropriate site near the river bank after conducting necessary geophysical studies. This site could be developed for a production well from where water could be treated for bacteriological contamination and supplied to the villages through ESRs and distribution network so as to reach every household. This system has inherent advantages of tackling lesser turbidity and bacteriological contamination as compared to conventional intake wells/ galleries on the banks of the river. Another important feature in Uttarakhand is the system designed is based on demand generated from the community and therefore the community (VWSCs) manages its own water supplies and undertakes O&M on their won. The Team recommends that a team of engineers visit Haridwar and other areas where such systems have been commissioned and working successfully. **The Team recommends construction of one or two projects based on river bank filtration and then scale it up, based on the success achieved. Shri G.P.Kimothi, Secretary(Appraisals), Uttarakhand Jal Sansthan, Dehradun could be contacted for technical details of the scheme.**

3) Capping of arsenic affected habitations is an established technology of CGWB for accessing arsenic-free drinking water from the deeper aquifer systems. However, UP Jal Nigam should understand where such capping is effective. For capping to be effective, a clay thickness of 3m is required. **It is observed that some of the deep tubewells have been capped where there is little thickness of clay. This may result in leaching of arsenic from the upper to lower aquifer systems.** This warrants for capacity building of UP Jal Nigam engineers. **CGWB should consider training UPJN engineers duly explaining the lithological sequences.**

4) The sealing has to be commensurate with the geophysical logging done before commissioning of the tube-well. (Please see Fig-2)

Fig-2
Design of the tube-well based on Geophysical log.



5) The following design of the groundwater abstraction structures is recommended.

The well assembly for moderately deep tubewells may be with 50 metre housing and tapping 30 to 40 meters of granular zone. After lowering of well assembly tubewell should be developed initially by air compressor followed by turbine pump till water is sand free. The depth wise suitable slot sizes are as follows:

S. No.	Depth (m)	Slot Size
1.	Down to 200	1.25 mm 1.55 mm
2.	200-350	0.75 to 1.00 mm

6) When new water supply systems are being commissioned, UPJN may consider maximum of10 ppb as desired level of arsenic in drinking water, though 50 ppb is the current BIS standard.

7) It is important to understand that arsenic problems exist only in places where availability is abundant ie., near the banks of major rivers Ganga and Ghagra. Therefore, the problem should be perceived as "**ARSENIC AND BACTERIOLOGICAL CONTAMINATION" rather than mere "ARSENIC CONTAMINATION". Rising of hand pump platforms, which is done in few sources in the district should be given high priority.**

8) Shallow hand pumps are found almost in all households and people are consuming contaminated drinking water, mainly due to vicinity and convenience. In some pockets, in Ballia district, even shallow aquifers were found having low level of arsenic contamination. **A well-structured awareness campaign should be immediately organized** to inform people about the ill-effects and consume only safe water for drinking and cooking purposes, though the sources may be slightly away, at present.

9) **100% testing of all drinking water sources should be conducted** by UPJN and **mark all sources with red paint wherever contamination is found**.

10) **Local people should be trained for testing quality** of drinking water by themselves using field test kits. Since arsenic field test kit is a stand alone system, these may be made available at the Block level in adequate numbers and BRC's recruited so as to bring the District administration and local panchayats together.

11) District water quality testing laboratory has the facility of testing arsenic only. This lab does not have the facility of testing bacteriological contamination and other chemical parameters which have to be monitored regularly. **Immediate upgradation of this laboratory is recommended along with adequate trained manpower.** At present, the lab has only one hired person who was found compete to test arsenic contamination only. This laboratory also require a facelift from civil works like proper plastering, finishing, white washing, replacement of corroded water pipelines with PVC pipes, etc.

12) As demanded by local people at few places during the field visits, a **2-day camps should be immediately conducted and the local people be explained about the arrangements being made for providing arsenic-free water from deeper aquifers**. They should also explain regarding the one-time household connection charges (Rs 500 per household) and monthly water tariff (Rs 18 per month per household).

13) It is found that the Village Water and Sanitation Committees are either non-functional or have not been constituted. **Strengthening VWSC is one of the key requirements for a sustainable water supply system.**

14) Mere installation of Arsenic removal plants (ARPs) by UPJN does not ensure availability of arsenic-free water to the villagers. Proper capacity building of villagers on line with the successful work initiated by Water Aid should be replicated in all 310 arsenic-affected habitations in Ballia district. It is heartening to note that 620 people have already been trained by Water Aid for undertaking O&M of arsenic removal plants. **The State Government may consider providing adequate incentives for these persons**. Since this forms a part of IEC activity, NRDWP-Support funds could be utilized for the purpose.

15) The ARPs were installed 2 years back in Ballia district. **The stage has come now to commission block level regeneration units.** The media (activated alumina) require regeneration with acid followed by neutralization after a period of 2-3

years. The BRCs could be given this responsibility with active support of Jal Surakshaks and functional VWSCs.

16) Sanitation status in the district is very poor. The District Collector also admitted the fact and has directed the DPRO to improve the status. **A proper communication strategy involving change agents on sanitation, school children, active involvement of NGOs like Inner Voice Foundation, Jal Surakshaks, ASHA and Anganwadi workers should be devised and make people convinced on the positive development they can be enjoy through proper environmental and personal sanitation**. Unicef and Water Aid volunteers shall extend full support for the achieving the Mission "**Swastha Ballia**".

17) The medical doctors including the CMO admitted that they lack capacities in diagnosing arsenecosis. **All Govt. doctors and if possible, select private doctors shall be given extensive training in this regard from Kolkatta Medical College, Jadhavpur University, etc. There should also be a separate department constituted in the District hospital for treating arsenecosis.**

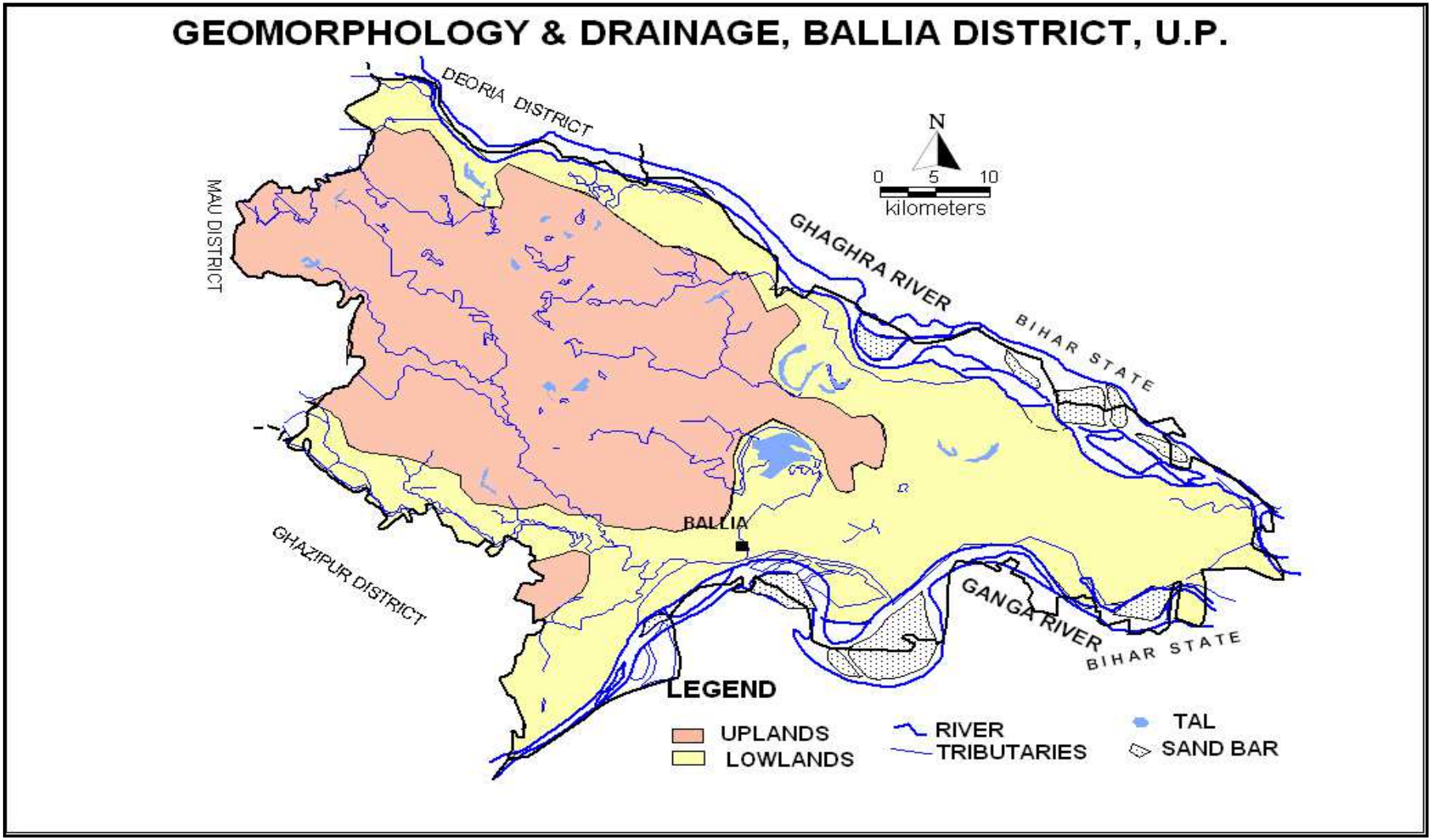
18) A **strong monitoring mechanism** involving WSSO at the State level should be set up and **proper convergence with NRHM and IDSP** be put into place for water quality monitoring and disease surveillance.

Acknowledgments

The Team would like to thank the Secretary and JS, MDWS for providing an opportunity to undertake such an extensive study. The Team expresses gratitude to the Principal Secretary, ED-SWSM, Director-WSSO, Mr. S.Kureel, CE and Shri R.M.Tripathi, Jt. Director of UP Jal Nigam for providing all logistic support. The Team would not only like to thank but also congratulate Mr. Saurabh Singh, who is taking all pains in mitigating arsenic related problems in Ballia district. The Team also puts on record the support rendered by officers of CGWB, Unicef and Water Aid.

(D.Rajasekhar)
Deputy Adviser (WQ) and
Team Leader – Central Team to Ballia district
Ministry of Drinking Water and Sanitation
Government of India
New Delhi

Map-1


GEOMORPHOLOGY & DRAINAGE, BALLIA DISTRICT, U.P.
DEORIA DISTRICT
MAU DISTRICT
GHAZIPUR DISTRICT
GHAGHRA RIVER
BIHAR STATE
GANGA RIVER
BIHAR STATE
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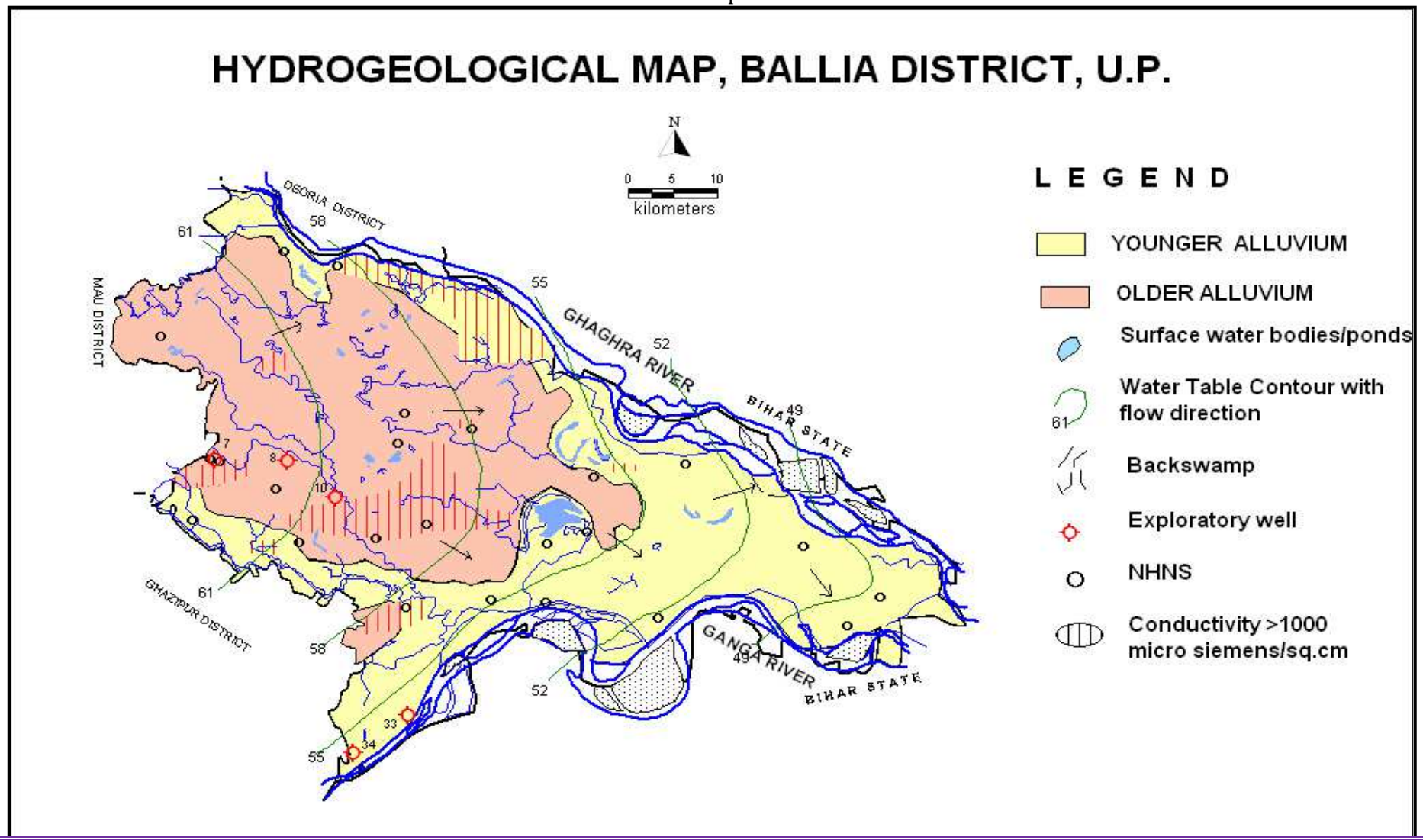
Map-2


HYDROGEOLOGICAL MAP, BALLIA DISTRICT, U.P.
N
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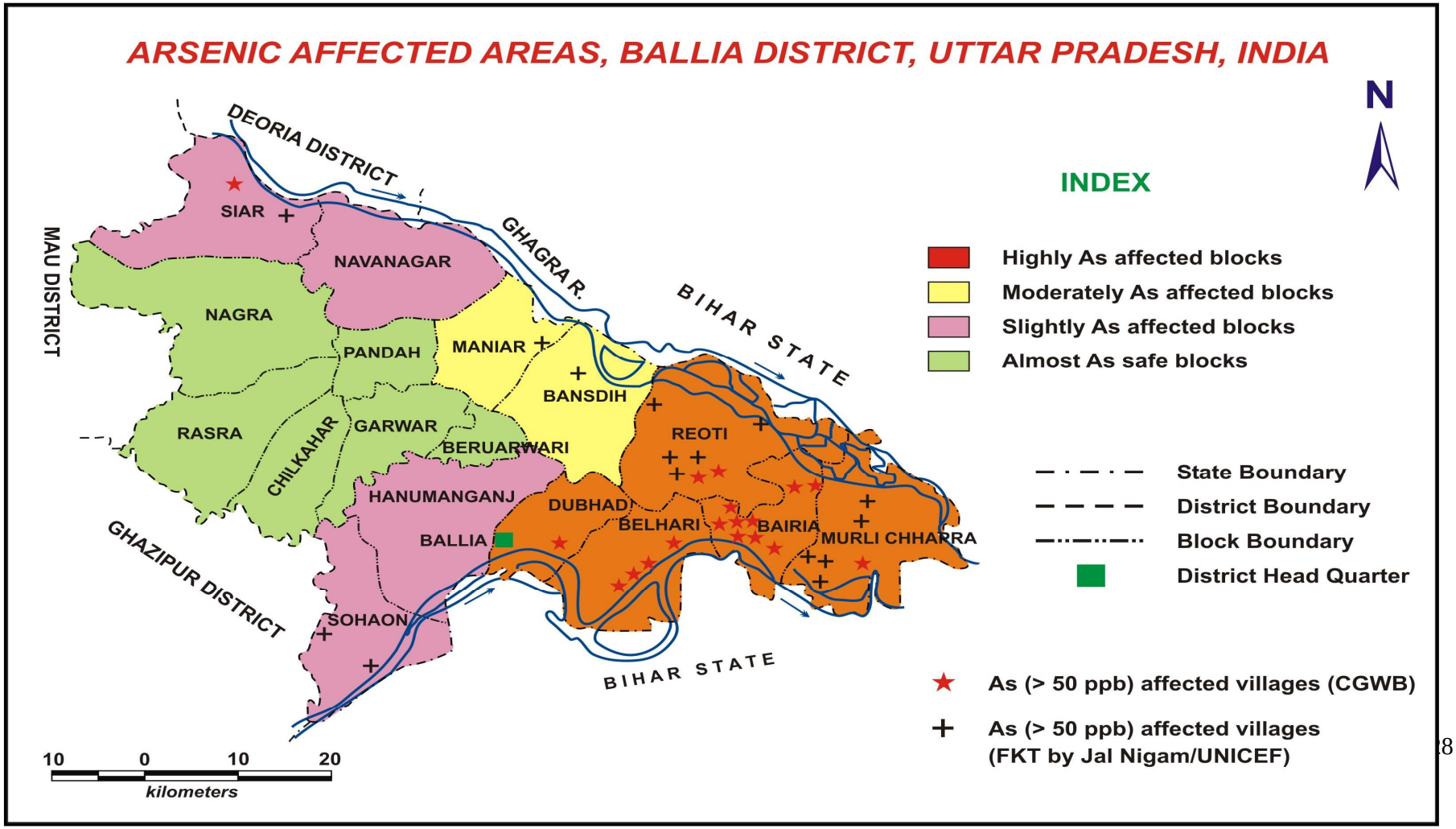
kilometers
DEORIA DISTRICT
MAU DISTRICT
GHAZIPUR DISTRICT
GHAGHRA RIVER
GANGA RIVER
BIHAR STATE
BIHAR STATE
61
58
55
52
49
61
58
52
49
55
L E G E N D
YOUNGER ALLUVIUM
OLDER ALLUVIUM
Surface water bodies/ponds
Water Table Contour with flow direction
Backswamp
Exploratory well
NHNS
Conductivity >1000 micro siemens/sq.cm

Map-3


ARSENIC AFFECTED AREAS, BALLIA DISTRICT, UTTAR PRADESH, INDIA
N
INDEX
Highly As affected blocks
Moderately As affected blocks
Slightly As affected blocks
Almost As safe blocks
State Boundary
District Boundary
Block Boundary
District Head Quarter
As (> 50 ppb) affected villages (CGWB)
As (> 50 ppb) affected villages (FKT by Jal Nigam/UNICEF)
DEORIA DISTRICT
GHAGRA R.
BIHAR STATE
MAU DISTRICT
GHAZIPUR DISTRICT
BIHAR STATE
SIAR
NAVANAGAR
NAGRA
PANDAH
MANIAR
BANSDIH
RASRA
CHILKAHAR
GARWAR
BERUARWARI
REOTI
HANUMANGANJ
DUBHADI
BELHARI
BAIRIA
MURLI CHHARRA
BALLIA
SOHAON
10 0 10 20
kilometers