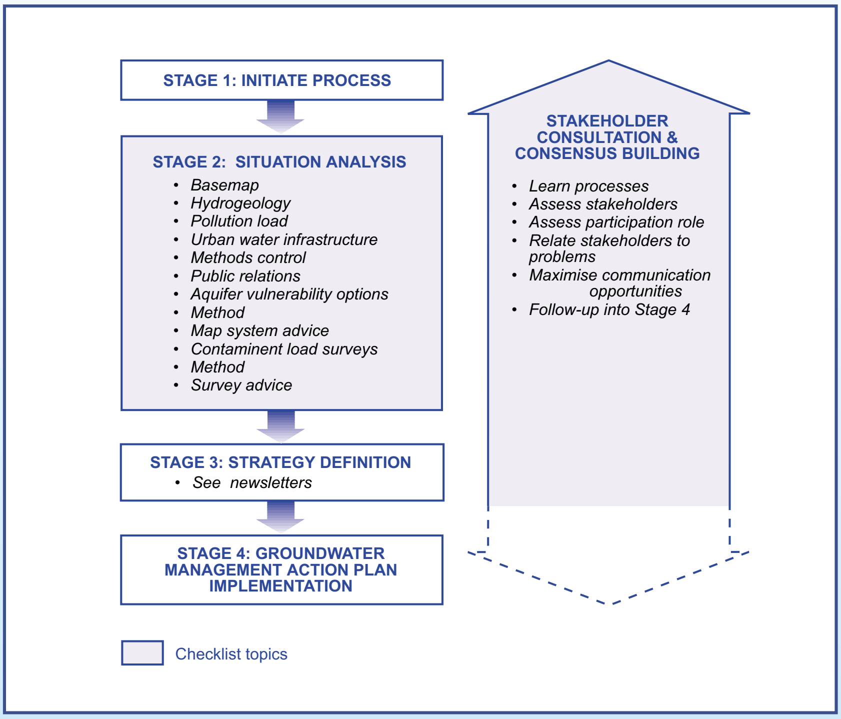

Urban Groundwater Questionnaire Tool
Urban Groundwater Profile Tool
Decision-Support System Tool
Consultation Process Tool
GROUNDWATER MANAGEMENT ACTION PLAN

CHECKLISTS


STAGE 1: INITIATE PROCESS
STAGE 2: SITUATION ANALYSIS
• Basemap
• Hydrogeology
• Pollution load
• Urban water infrastructure
• Methods control
• Public relations
• Aquifer vulnerability options
• Method
• Map system advice
• Contaminent load surveys
• Method
• Survey advice
STAGE 3: STRATEGY DEFINITION
• See newsletters
STAGE 4: GROUNDWATER MANAGEMENT ACTION PLAN IMPLEMENTATION
STAKEHOLDER CONSULTATION & CONSENSUS BUILDING
• Learn processes
• Assess stakeholders
• Assess participation role
• Relate stakeholders to problems
• Maximise communication opportunities
• Follow-up into Stage 4
Checklist topics

Overview

This section provides checklists for Stage 2 of a Groundwater Management Action Plan for a city that utilises aquifers below or close to the city (in the periurban fringe). The checklists are ordered in the typical sequence of an Action Plan work programme: data collection and analysis, vulnerability and contaminant load assessments (Figure 1). References to reports with more information on the techniques described, or with worked examples, are included at the end of each checklist sub-section.

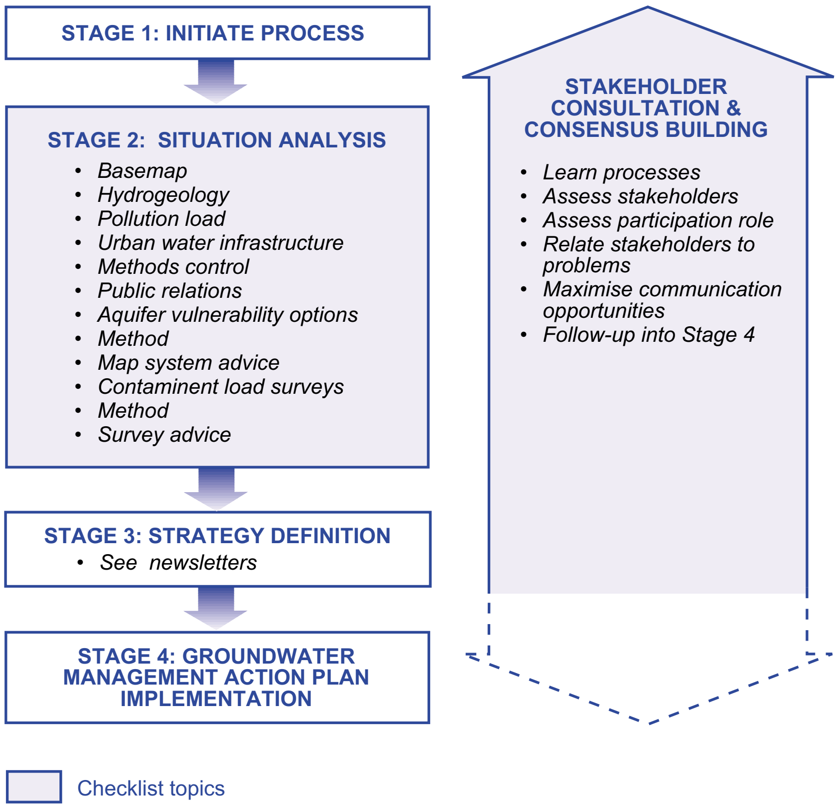


Figure 1 Checklist notes for staged development of management strategy

Data collation and analysis

General orientation:

- Inspect orientation material on Urban Groundwater Development: Guide to Data Acquisition and System Characterisation on World Bank website[1]. This site provides 19 downloadable reference documents and 15 city case-study examples specifically designed for urban groundwater assessment orientation purposes. Use the Urban Groundwater Questionnaire tool to provide a concise summary of groundwater status for the city, organise and prioritise data collection and identify data deficiencies.

[1] Consult http://lnweb18.worldbank.org/ESSD/essdext.nsf/18ByDocName/SectorsandThemesGroundwaterGroundwaterinUrbanDevelopment

Advice or items to check, classified by topic

BASEMAP:

- Establish whether modern good quality topographic maps at scales 1:25,000 to 1:50,000 are available for the city area/surrounds. Topographically accurate (not schematic) versions are required to provide linear/point data for basemap and site location coordinates[2];
- If unavailable, seek alternatives (airphoto/TM remote sensing image);
- If use of national grid coordinates is sensitive, establish coincident city-specific grid with periurban 0,0 origin.

HYDROGEOLOGY:

- List, establish contact with and visit all likely sources of hydrogeological data (state institutions, national surveys, universities, municipal civil engineering projects, water utility, water-well drilling companies, donor agency libraries);
- Even in cities with hundreds of production boreholes, be prepared for sparse monitoring well data, both on water levels and water quality. Even where data exists it may not be systematically stored, have hiatuses or be held by agencies not initially willing to share (inter-agency competition). Be open about what the data are to be used for, and if appropriate, consider small data preparation/ consolidation contracts for agencies holding valuable but hard-to-access information. Remember- available data were not produced for your benefit, so do not expect well-organised, up to date, comprehensive or readily available sources;
- For geology, inspect data, focusing on what will provide criteria to establish (a) groundwater setting (geometry/disposition of aquifers/ aquitards/aquicludes, formation physical properties/flow systems) and (b) intrinsic vulnerability classification;
- For water levels/quality, use existing contour/other parameter distributions maps, or identify sufficient data points to inform judgements on flow directions and mechanisms and baseline water quality;
- For abstraction patterns, identify main groundwater users and uses. If data from users/regulator on abstraction patterns/quantity unavailable, estimate by classifying water use type (public supply from water utility, public/private industrial, private domestic, institutional, agricultural etc), typical installation (borehole with electric pump, shallow well with handpump etc), operating regime and number of units. Conduct citywide or selective survey to supplement available data if volumetrically important user group not represented.

POLLUTION LOAD:

- List, establish contact with and visit all likely sources of water quality data (state institutions, public health department, national regulatory/environment agency, universities, water utility, beverage and food processing industry, NGOs, donor agency libraries);
- When assessing available data, check first the easily measured parameters (electrical conductivity, major ion analyses, faecal indicators). These are typically much more widespread, and could indicate both geographical extent and temporal trends through water quality maps or graphs of time-series data from surveillance wells;
- Supplement with site–specific pollution event data but avoid risk of concentrating on one or two sites at expense of the broader picture. Actively seek data from 'early warning' sites (shallow wells tapping the uppermost 20-30m of aquifer as well as trend indications from public supply/beverage production wells. Try to identify well-established districts

[2] Refs 27, 30, also consult national mapping agency or commercial outlets e.g. http://www.omnimap.com/maps.htm

representative of city's main land-use types/activities, especially central districts, industrial zones and up-gradient of major potable supply wellfields;

- For industry surveys, think laterally-check for information already compiled for other purposes e.g. trade, commercial and Yellow Pages-type directories, factory inspection registers, national census returns, business investment/trade association/Chamber of Commerce membership guides;
- Do not forget to include sites which are located by accident or design outside formally-designated industrial zones or activities which are not classed as industrial but could generate important contaminant loads e.g fuel filling stations or pesticide storage depots may be classified as distribution rather than industrial activities;
- Remember much statistical material may be very dated, especially if derived from 10-year censuses. Interpretation should take current and likely future trends into account e.g. Most military-industrial plants operating in Bishkek in mid-1980s were totally defunct by late 1990s, while the handful of state fuel filling stations has been replaced by scores of profitable new commercial stations proliferating throughout the city. Thus one whole area of potential contaminant problems has been reduced to a legacy problem, a new one created and neither trend showed in available statistics.

URBAN WATER INFRASTRUCTURE:

- List, establish contact with and visit sources of data for estimates of the extent of piped potable water, district heating, sewerage and on-site wastewater effluent disposal (water utility, municipal public works and public health departments). Avoid detail, concentrating on establishing approximate geographical extent of piped networks, proportion of effluent producing industry served, extent of mixed sewered and on-site arrangements and likely magnitude of leakage from each utility.

METHODS CONTROL:

- For all sources of data, interpreted material and supplementary field surveys used in the project, assign simple qualitative confidence ratings. This allows both uncertainties due to lack of knowledge of system and predictions that can be confidently based to be given their due weight at final stages of protection policy development (options selection);
- Establish logical and transparent data management system enabling easy access, updating and archival of the diverse datasets used in protection plan technical assessments. To cover both paper records and digital data;
- For all map production, but especially if using a GIS, document metadata (data about data) so that technical decisions made during the mapping process are recorded. Important both for continuity of approach within project and to enable maps produced by the project to be used subsequently e.g by planning or regulatory agencies.

PUBLIC/STAKEHOLDER RELATIONS:

- Establish a clear data confidentiality/ protection policy before data collection starts, so that those holding data know where they stand on its future use. Much information can be anonymised on databases without losing specificity or statistical value;
- Be aware of local sensitivities especially when dealing with stakeholder groups or those likely to influence such groups e.g. periurban communities fearful of urban encroachment, industries' commercial or regulatory suspiciousness, lobby groups selectivity of data for own agendas, local news media more preoccupied with headline sensationalism than factual accuracy, jealousies between institutions with overlapping responsibilities etc;
- Plan field surveys to take account of urban realities, especially if regular monitoring is involved. Site monitoring wells in locations that will minimise risk of vandalism but ensure

continued freedom of access for measurements/sampling. Water utilities are invariably valuable sources of raw data, water infrastructure statistics and access for monitoring etc. Be sensitive to their schedules and work programmes- many utilities are under-resourced and struggle to meet their water supply/wastewater responsibilities;

- Writing a short jargon-free news release/interview for the local news media. This informs stakeholders and can help pre-empt journalistic temptation to exaggeration. Avoid unnecessary technical terms and contentious issues, keep principles simple and remember editors prune from the end backwards towards the front, so make main points concisely early in the article.

WHERE TO FIND MORE DETAILS

References: BGS *et al* 1994, BGS & Cooperativa de Servicios Públicos "Santa Cruz" Ltda 1995, BGS & Cooperativa de Servicios Públicos "Santa Cruz" Ltda 1997, Foster & Hirata 1988, Johansson *et al* 1997, Leitmann 1994, Morris *et al* 2000, Morris *et al* 2001, O'Dochartaigh *et al* 2000.

Supplementary field surveys

Surveys to assess aquifer vulnerability

LEARN ABOUT OPTIONS:

- Consult NRC (1993), Vrba & Zaporozec (1994) for background on principles and concepts and for descriptions of different methods of intrinsic vulnerability mapping.

CHOOSE METHOD:

- Critically assess existing hydrogeological, soil and recharge data, resources available to supplement deficiencies (staff, funds, logistics) and actual city conditions (coastal/inland conditions, topographic constraints, extent of near-surface disturbance etc);
- Choose most applicable intrinsic vulnerability approach that will not only employ key intrinsic vulnerability factors (those ranking inaccessibility of aquifer to surface-generated loads)but also will make best use of the data with the highest confidence rating e.g. in Bishkek good pre-existing hydrogeological studies dictated the factors that were chosen.

CHOOSE MAP SYSTEM:

- Choose method of map production appropriate to circumstances of team expertise, drafting and IT resources (manual or GIS systems), or of scope to out-source specialist skills. If using manual methods, include costs of multiple map printing in estimates;
- If using GIS afresh, assess and choose in terms of extent of national use, ease of transfer of data products to other systems, availability of local training as well as initial cost. Ensure that chosen software allows produced maps to be easily imported into, and faithfully reproduced, in reports, newsletters etc. Automatically include a comprehensive training programme for new GIS operators as the skill requirements for dextrous use of GIS are high.

KEEP METHOD HYDROGEOLOGICALLY SENSIBLE:

- If using index-and-overlay method, select indices and weighting factors according to sound hydrogeological principles e.g. selecting factors which control hydraulic accessibility, then document selection procedure. Subjectivity is quite justified in selecting weighting factors as long as the basis is clearly recognised and documented (e.g. less weight on parameters which have been inferred or have low confidence levels);

- Keep indexing system as simple and transparent as possible and try to avoid 'unstable'combinations (widely divergent vulnerability ratings for same area from single minor change in value of one input parameter)

EXCLUDE UNWORKABLE ANOMALIES:

- The overlay process will often produce very small anomaly areas to which it would be difficult to apply, and justify, policies. Agree a protocol for manual adjustment of the vulnerability map at the stage at which it becomes part of the base layer for the Groundwater Resource Protection/Planning Map (GRPM). For an example, see the Bishkek vulnerability map in Appendix Figure 4.1. which was subsequently adjusted to become the Bishkek GRPM in Figure 9.

DOCUMENT PROCESS:

- Produce a technical report that clearly documents procedure and stages so that the evolution of the final map can be clearly traced

WHERE TO FIND MORE DETAILS

References: Johansson *et al* 1997, Morris *et al* 2000, Morris *et al* 2001, National Research Council 1993, Vrba & Zaporozec 1994.

Surveys to assess contaminant load

LEARN ABOUT OPTIONS:

- Consult Foster & Hirata (1988), Leitmann (1994) for background and helpful generic tables.

CHARACTERISE CONTAMINANTS:

- Using data assembled from Phase 1, characterise likely distribution (diffuse, point, linear), nature (faecal pathogens, heavy metals, salinity, LNAPL/DNAPL etc) and extent of pollution load for different sectors of the city (residential, industrial, commercial, periurban zones).

SUPPLEMENTARY FIELD SURVEYS:

- Compare results with available resources to assess whether supplementary field studies are required. Contaminant load field studies are highly resource intensive and may need to be phased (e.g. first-pass→pilot→detailed). Supplement city-specific data with generic information from studies elsewhere to infer pollutant types/loadings. Clearly separate inferences from documented/factual base.
- Access to industrial raw material use/storage or effluent information (especially if toxic) is usually difficult even through regulatory agency records; in their absence field surveys may not be practicable.
- Avoid judgemental attitudes when collating and interpreting site-specific or industry-specific contaminant issues- while some irresponsible effluent disposal is deliberate, many entrepreneurs are just not aware of the consequences of their activities. This is especially true of small-scale industry. (small to medium enterprises or SMEs).

- If data on actual contaminant loads is poor/absent, identify main sites likely to be generating an effluent stream through potentially polluting activities survey and cross-check with typical mode of waste disposal to infer extent, nature and likely intensity of subsurface pollutant load. Stress that survey is of potential, not actual pollution, avoiding future charges of unsubstantiated insinuation by stakeholder groups during consultation stage.

WHERE TO FIND MORE DETAILS

References: Foster & Hirata 1988, Leitmann 1994, Morris *et al* 2000, O'Dochartaigh *et al* 2000.