Stage 3 – Strategy Definition

Characterising and Prioritising Groundwater Pollution Threats –

DECISION-SUPPORT SYSTEM TOOL

Structure of Tool

A simple decision-support system (DSS) has been developed to help the non-specialist characterise and prioritise groundwater pollution threats according to their type, source, severity, scale, and possible impact on different end uses and users. The DSS is available in both electronic (Excel 97 spreadsheet) and manual (paper copy) forms. The latter is based on the tables presented in Decision Support Tables, with results computed manually. Instructions on how to work through both versions are given in the User Guide below.

Specifically, the DSS draws on the data generated by the Urban Groundwater Questionnaire and a series of 'lookup' and 'cross-tables' to determine:

a) the **type of contaminants** that might be produced in different cities, based on a classification of urban activities and information on wastewater disposal arrangements. The classification is based on a standard industrial coding system (also used in the Questionnaire) to achieve consistency and to allow cross-city comparison. Eight key contaminants are identified, including pathogens, organic loads, heavy metals and solvents. Lookup tables provide information on which urban activities produce which contaminants. This is done automatically in the spreadsheet version.

b) which of these contaminants are likely to **reach the water table**, based on typical aquifer travel times and contaminant persistence. The travel times for the major aquifers, based on aquifer type, degree of confinement (protection) and depth to water table, are provided in a lookup table, as is typical persistence time for each contaminant.

c) how **widespread and severe** the resulting contamination might be, based on contaminant type and the hydrogeological environment.

d) whether the contamination problem, or hazard, poses a **threat to different end users/uses**, and **how soon the use/user might be affected**.

The DSS can be used to assess future risk to urban groundwaters, and to help characterise existing problems. In the latter case, for example, the DSS could be used to guide monitoring efforts and identify likely contamination sources where groundwater quality has already deteriorated. In this respect it complements, rather than substitutes for, direct monitoring of resource conditions.

In its present form, the DSS does not provide detailed information on (d) above. The emphasis is on characterising pollution threats, rather than working through context-specific policy options.

Approach

The DSS was developed to meet the following criteria:

a) **Integration:** the system developed needed to be compatible with the diagnostic, and with other elements of the planning process. To achieve this, the DSS uses only those data generated by the Questionnaire.

b) **Applicability:** the system needed to be of use in a wide range of urban groundwater settings.

c) **Consistency:** the system needed to produce results that are comparable across cities.

d) **User friendliness:** the system had to be easy to use and easily understood by the non-specialist, including those without access to a computer, or with few information technology (IT) skills.

e) **Utility:** results needed to provide insight into the nature of existing or potential problems, providing support for groundwater management decisions, though stopping short of identifying appropriate management options as these would be case-specific.

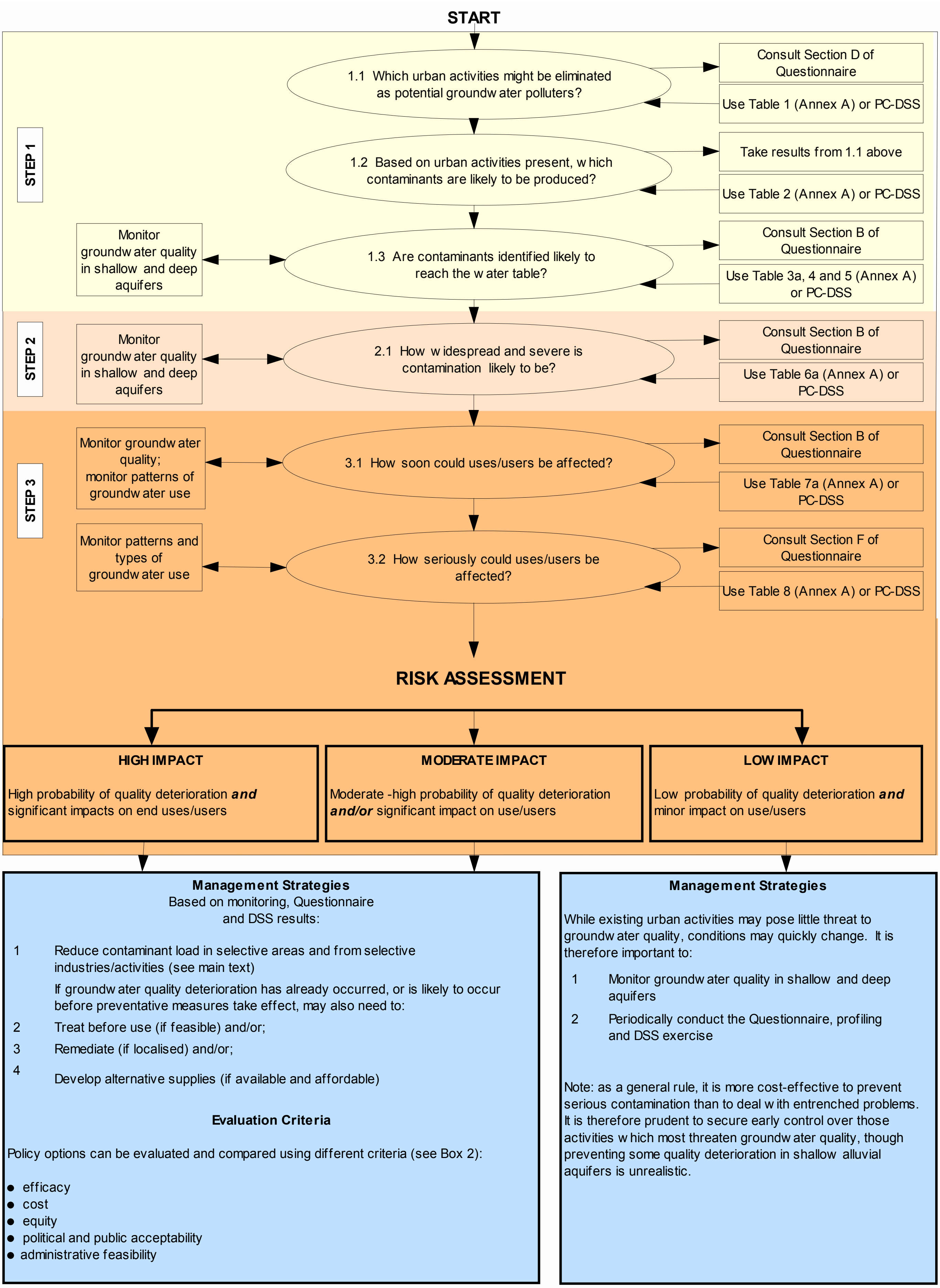

Figure 1 **Flow chart illustrating Decision Support System structure with sample management strategies to mitigate pollution impacts**

Figure 1 is a flow chart which shows the structure of the DSS. It is based on three progressive question 'steps' (colour coded in the figure) as follows:

- *STEP 1*. What major contaminants may be present in the urban area?
- *STEP 2*. How widespread and severe is contamination likely to be?
- *STEP 3*. How soon, and to what extent, could groundwater uses and users be affected?

Data to answer these questions are drawn from the Questionnaire according to the guidelines described in the section below. The tables presented in Decision Support Tables help process and interpret the data. Three types of table are provided:

Lookup tables: these help the user interpret the information collected in the Questionnaire by classifying it into scores, ranks, simple descriptions or figures.

Crosstables: these bring together ranks, scores or figures from two or more lookup tables to give an overall score for one particular characteristic.

Information-only tables: these supplement the lookup tables by providing further information on a particular topic. Although they are not currently used in the DSS, they could be used in its further development.

The DSS can be run on a personal computer[1] (as an Excel 97 spreadsheet), or worked through manually using the tables in Decision Support Tables. The tables support both the manual and electronic versions of the DSS. Working through the tables manually allows more flexibility and scope for judgement in interpreting data; the PC-based DSS generates results by using pre-set scoring and ranking systems embedded in macros (see Narayanganj example for computer screen images of spreadsheet). These macros use the lookup tables, which are shown on the spreadsheet for information purposes.

Figure 1 also illustrates how DSS results could be used to begin the process of identifying and evaluating alternative management strategies. Three possible risk assessment outcomes and associated options are highlighted, and discussed further in the strengths and weaknesses section of this document.

User guide

The User Guide below provides instructions for working through Stages 1-3 of both manual and electronic versions of the DSS. Users should refer to Figure 1 for navigation as they proceed.

Although separate instructions are provided for manual and spreadsheet versions, it is recommended that those using the spreadsheet read *all* of the instructions. This is because the scoring and ranking systems used in the spreadsheet are based on the 'manual' tables presented in Decision Support Tables.

Thoughtful interpretation of the options is needed to account for gradations for example in methods of waste disposal or geological protection of the aquifer. The reasons for any decision should be documented.

It is important to emphasise that the DSS does not provide 'all the answers' needed to manage urban groundwater. Rather, it provides a first-pass assessment of contamination threat, based on a limited set of data and many simplifying assumptions. In the interests of transparency, key assumptions are listed in the User Guide at the end of each sub-section.

It is recommended that the spreadsheet version be used. The manual tables are therefore presented separately.

[1] To run Excel 97, the computer will need to have Windows 95 (minimum) installed.

STEP 1: WHAT MAJOR CONTAMINANTS MAY BE PRESENT IN THE URBAN AREA?

1.1 Question

Based on urban activities and wastewater disposal arrangements, which urban activities may potentially contribute to groundwater pollution?

Data sources

Sections D1 and D3 of the Urban Groundwater Questionnaire; Tables 1A of Decision Support Tables

Instructions

For each of the urban activities present in the city (from Section D3 of Questionnaire), use Table 1A to determine the likelihood of troublesome contaminants being released to ground beneath the contaminant source. Activities not present, or activities that score LOW (disposal via sewered or lined collector drains) could be excluded as potential sources of contamination, though users are encouraged to apply local knowledge to determine scores. Record scores.

Turn on your **PC**, insert the **CD-ROM**, open the file **Stage 3 DSSv4.xls** and click on the "Enable Macros" box. Save a copy to your own PC for your own entries. On the **PC-based DSS**, activities and disposal methods are selected by clicking the appropriate boxes on the Data Entry Table, 'Urban Activities and Waste Disposal Methods'. Clicking on the 'Table Update' button generates scores of HIGH, MED or LOW for each activity, indicating *potential* attenuation for alternative disposal methods. While activities that score LOW *could* be excluded as sources of potential contamination, the spreadsheet defaults to a worst case scenario of 'on-site disposal via soakaway or unlined collector, or by latrine/cesspit' for all activities. This is to allow for possible variations in disposal arrangements within the same activity groups.

Notes/assumptions

- At present the tables and PC-DSS do not account for SOLID WASTE disposal arrangements, though Section D4 of the Questionnaire does ask questions about these.
- No account is taken of wastewater TREATMENT, as different disposal methods are assumed to carry a fixed risk. In reality, disposal via sewers or lined collector drains could be classified as high risk if wastes are simply disposed of elsewhere with no prior treatment. Table 1b of Decision Support Tables (included in this version for information only) could be used to refine results.
- Similarly, no account is taken of VARIATIONS in disposal methods within activity groups. The PC-based DSS is precautionary and defaults to the 'worst case' disposal method (see above), irrespective of the selection made in the drop-down menu.

The lookup tables on the PC-based DSS require no data entry, being used by the macros for computation purposes.

1.2	**Question** Based on the composition of urban activities (see 1.1), which contaminants are likely to be produced? **Data sources** Results from 1.1 above; Table 2 of Decision Support Tables (in PC-version, results from 1.1 and Lookup Table 1) **Instructions** For each activity present in the city and (optionally) scoring MOD or HIGH in 1.1 above, use Table 2 (Decision Support Tables) to determine the likelihood of contaminants being present in hazardous quantities. Table 2 lists 8 main contaminant groups; the maximum score for each should be recorded where several activities produce varying amounts of the same contaminant. Enter scores in column 2 of the Main Result Table (Table MR). For users of the PC-DSS, this is done automatically, using Lookup Table 1 and the results from 1.1 above. The **PC-DSS** generates automatic scores for each contaminant type (unlikely; probably; or very likely to be present), based on the maximum score recorded for each. Scores appear in the first column of the Main Results Table (worksheet 3) when the Table Update button is clicked. Reminder: the spreadsheet currently defaults to the worst case disposal method (see 1.1 above). **Notes/assumptions** • Going through the tables manually in Decision Support Tables allows more scope for use of local knowledge and judgement in deciding which contaminants may be present, and what the principal contaminant sources are likely to be (e.g. knowledge of composition and concentration of urban activities in relation to aquifer vulnerability). The tables in Decision Support Tables also provide some additional information in the form of footnotes. • The PC-DSS does, however, provide a quick, first-pass assessment of contaminant threat based on the simple scoring and classification methods described above.

1.3	**Question** Based on typical travel times to the aquifer, and the persistence of contaminants, what is the likelihood of contaminants reaching the water table? **Data sources** Section B of the Questionnaire; Tables 3a, 4 and Cross-table 5 (Decision Support Tables). (In the PC-DSS, Section B of the Questionnaire and Lookup Tables 1, 2 and 3 (based on Tables 3a, 4 and cross-table 5 of Decision Support Tables). Look-up 3 is a cross-table) **Instructions** Using the data generated in Section B of the Questionnaire, define your hydrogeological environment according to (a) aquifer type; (b) degree of confinement; and (c) depth to water table. Use table 3a (drawing on data presented in Table 3b – for information only) to find the typical travel time for this type of aquifer. Note the MINIMUM travel time given. Then, for each contaminant group likely to be present (from 1.1 and 1.2 above), use Table 4 to assess its persistence; where a range is given (e.g. moderate-high), take the upper value. Use Cross-table 5, which jointly scores persistence and travel times, to determine the likelihood of contaminants reaching the water table. Enter scores for each contaminant in column 3 of the Main Results Table. On the **PC-DSS**, use data from Section B of the Questionnaire to complete the second Data Entry Table on the groundwater system. Click on the Table Update button of the Main Results Table so that the macro computes the likelihood of different contaminants reaching the water table (it uses scores from Lookup Tables 1, 2 and 3A for this purpose). These scores are displayed in column 2. **Notes/assumptions** • Ideally, the scoring procedure should be carried out for each aquifer if the aquifer system comprises a multi-layered sequence (aquifer 1, aquifer 2 etc).

STEP 2: HOW WIDESPREAD AND SEVERE IS CONTAMINATION LIKELY TO BE?	
2.1	**Question** Based on the hydrogeological environment and contaminant types identified, how widespread and severe is contamination likely to be? **Data sources** Section B of the Questionnaire; Tables 6a, 6b, 6c (in PC-DSS, Lookup Table 4 (based on Table 6a above) is used to compute results, drawing on data entered in Step 1) **Instructions** For each contaminant type identified as likely to be present, use Table 6a (based on information-only tables 6b and 6c) to assess its potential to cause severe and widespread contamination for the hydrogeological environment in question. This potential is assumed to be a function of both contaminant mobility and persistence as controlled by attention processes (Table 6b), and aquifer characteristics influencing contaminant transport (Table 6c). For example, following a spillage of chlorinated solvents, the contaminants are likely to persist and remain mobile in groundwater, and thus have a high *potential* to produce a widespread plume (Table 6b). However, in major alluvial aquifers (high attenuation capacity – Table 6c) this plume is likely to develop only slowly because of low groundwater velocities, so overall potential (Table 6a) is scored as moderate. Enter scores in column 3 of the Main Results Table. The **PC-based DSS** uses Lookup Table 4 to generate these scores. Click on the Table Update button of the Main Results Table to reveal scores (column 3). **Notes/assumptions** • For simplicity, it is assumed that contaminant sources are point rather than diffuse sources. Hence times given are from initial point source release. • No account is taken of the influence of the groundwater pumping regime (volumes; depth; distribution) on hydraulic gradients, and hence on contaminant movement. • In reality, abstraction boreholes may intercept plumes. This has the advantage of preventing further spread of contaminants but the disadvantage of adversely affecting the quality of the discharge from the intercepting well.

STEP 3: HOW SOON, AND TO WHAT EXTENT, COULD GROUNDWATER USES AND USERS BE AFFECTED?	
3.1	**Question** Based on the hydrogeological environment, how soon could users/uses be affected by the potential contaminants identified? **Data sources** Section B of Questionnaire; Table 7 of Decision Support Tables. (In the PC-DSS, the time intervals given in Table 7 above are incorporated into a spreadsheet macro; there is no Lookup Table) **Instructions** For the hydrogeological environment identified for your city, consult Table 7 to find the typical time intervals for contaminants to move laterally and vertically through the aquifer. Enter result at bottom of the Main Results Table. In the **PC-DSS** click the Table Update button on the Main Results Table to generate a score and time in the Indicative response window.
(3.2)	**Question (information only – not currently incorporated in DSS)** How seriously could the use/user be affected by the potential contamination identified? **Data sources** Section F of the Questionnaire; Table 8 of Decision Support Tables **Instructions** • Table 8 provides a broad indication of water quality needs for different urban activities and the potential impact of different contamination problems on the water end-use. This is an information-only table and is not used to generate scores in the Main Results Table. • The PC-DSS does not consider potential impacts on uses/users. **Notes/assumptions** • At present the DSS does not incorporate the data needed to consider the range of possible impacts of groundwater quality deterioration on end uses/users. Table 8 (Decision Support Tables), not currently included in the DSS, only gives a very simple indication of impacts. • Users are encouraged to consult Section F of the Questionnaire if they wish to follow up Question 3.2 more fully. The sensitivity of society, and the economy, to contamination impacts is related to may different factors, but key factors include: level of dependency on groundwater; sensitivity of uses to quality deterioration; the opportunity cost of pollution (of alternative supplies/of remediation/treatment); and the capacity (financial; institutional) to mitigate problems (see Box 1).

	SUMMARY
	The Main Results Table (MR) is now complete, and should give scores for each main contaminant group for: 1. The likelihood of the contaminant being present (released to ground) in your city 2. The likelihood of the contaminant reaching the saturated aquifer 3. The potential of the contaminant to cause severe and widespread pollution In addition, the table should now give: An indicative response time before contaminants (unspecified) threaten a groundwater use/user group

Identifying management needs

The current focus of the DSS is on problem identification and prioritisation, rather than detailed evaluation of alternative management options. Nevertheless, Figure 6.1 does highlight three possible risk assessment outcomes and associated options. These are discussed briefly below, together with supplementary methodology for analysing problems and drawing out management needs. Those wishing to find out more about groundwater management strategies for urban areas should consult the list of five key references at the back of this report.[2]

DSS outcomes and groundwater management strategies – an overview

1. High impact

"High probability of quality deterioration and significant impacts on end uses/users"

In situations where serious groundwater contamination is likely, *and* where impacts are likely to be severe (see Box 1), a priority is to control those activities which overall, most threaten groundwater quality and especially that in deeper (less vulnerable) aquifers. Once DSS and direct monitoring results have been analysed, this is likely to involve selective controls on subsoil contaminant loading. While the precise mix and level of measures will vary according to local circumstances (aquifer vulnerability; the characteristics of water pollutants involved, and patterns and purposes of groundwater abstraction), they are likely to include:

- Extension of mains sewerage into areas of high aquifer vulnerability or in the environs of source protection zones, especially if these are highly industrialised areas.
- Land use zoning for priority control of contaminant loads, with restrictions on certain types of development (e.g. heavy industry) in vulnerable areas, and spatial separation of waste disposal and water supply.
- Controls on landfill location and design.
- Stimulating waste reduction, recycling and integrated pollution control through education and awareness raising, dovetailed with regulatory controls and economic incentives.

Some examples of policy instruments for this purpose are listed in Section E3 of the Urban Groundwater Questionnaire Various policy criteria can be used to compare alternative options and strategies. These are discussed in Box 2.

[2] In particular, Lawrence et al. (1997), Foster et al (1998) and Salman (1999).

It is important to note that, just as groundwater quality deterioration is likely to occur over timescales stretching to decades, so reversal of adverse water quality changes will also be protracted. In situations where control measures are unlikely to prevent short-medium term problems, are too difficult/costly to implement, or where groundwater quality deterioration has already occurred, addressing the symptoms of degradation, as well as the causes, may be necessary. This may involve:

- *Groundwater treatment*. Treatment options may be expensive, however, and impossible to implement where small scale, private abstraction is prevalent.

- *Groundwater remediation*. Remediation may be viable for small scale, point source incidents, but is unlikely to be viable for dealing with widespread and entrenched problems.

- *Development of alternative supplies, if available*. This may include, for example, substitution of city centre abstraction by out-of-town supplies, though the costs of 'next best' alternatives are usually higher when compared on a like-for-like basis. For example, where groundwater is withdrawn by many 'private' abstractors (households; industries), substitution costs may include the cost of providing a reticulation system to distribute the new water as well as the cost of developing the source itself.

2. Moderate impact

"Moderate to high probability of quality deterioration, and/or significant impact on end uses/users"

In situations where some contamination may occur (or has already occurred) with impacts on end uses/users, the management strategies outlined above will apply, though the need for action may be less urgent. In circumstances where groundwater is little used, or where users are likely to be unaffected by quality changes, no action beyond the monitoring of groundwater quality and patterns and types of use may be required.

It is worth emphasising that urbanisation and patterns of groundwater exploitation and use can change very quickly, and steps taken now to protect groundwater can bring benefits over the longer term should conditions change.

3. Low impact

"Low probability of quality deterioration and minor impact on uses/users"

This scenario might arise in the early stages of urbanisation when significant groundwater development and industrialisation have yet to occur. Even under these circumstances, however, it is important that action is taken to monitor groundwater conditions, groundwater usage and urban development, as an upsurge in groundwater exploitation often occurs in tandem with urban expansion and industrialisation. For this reason, it is recommended that the Groundwater Questionnaire, Profiling and DSS exercises are conducted periodically to identify incipient problems before they become entrenched, and much more difficult (and costly) to rectify.

Box 1 Contamination impacts

The DSS in its current form does not provide detailed information on the threat groundwater pollution may pose to different uses and users. To assess this, readers are encouraged to examine the information collected for Section F (Degradation Impacts) of the Questionnaire in the following contexts:

a) Level of dependency on groundwater

If, in proportional terms, groundwater is little used within the economy, its pollution may not be as significant as where it is the bulk provider of water. However, much will depend on the uses to which groundwater is (or could be) put. Where water quality is of little concern – irrespective of groundwater dependency levels – pollution may pose little threat. Such a situation might arise where groundwater is exploited by large industrial users or municipality for non-sensitive uses, such as cooling or amenity area watering respectively. However, where groundwater dependency is high and where water uses are sensitive to changes in quality, the impacts of pollution are likely to be more severe.

b) Opportunity cost of groundwater degradation

If alternatives to groundwater exist, then it follows that society and the economy are likely to be less vulnerable to potential groundwater degradation effects. This, clearly, is subject to the cost of such alternatives and their affordability to different uses and users. Experience from other urban settings where water scarcity is increasing suggests that alternatives are typically 2-3 times more expensive. Where groundwater abstraction is substituted by surface water development, the differential may be especially pronounced, particularly where groundwater is abstracted by private agents. In these circumstances, the cost and price differential will include the cost of providing a centralised reticulation system, as well as an alternative source of water.

c) Capacity to mitigate the problem

Sensitivity to a groundwater pollution threat is in large part a function of the capacity to mitigate its causes and/or effects. Financial and institutional capacity can be distinguished, though the former may help determine the latter.

Where the financial capacity to address causes and/or effects is high, groundwater degradation may be checked at an early stage or, alternatively, impacts can be mitigated more effectively. Thus, a sewerage system could be built to prevent seepage (address causes), or a treatment plant built to improve quality (address impacts). Alternative water sources will be more affordable, too.

Institutional capacity encompasses many different factors. However, key issues revolve around (i) the existence of economic incentives and regulatory controls in the water sector; and (ii) their application. The distinction is an important one as, in many developing countries, it is clear that even where such measures exist - at least indicating a willingness on the part of the state to recognise problems – the measures are often ineffective. A fundamental problem in many areas is the monitoring and enforcement of restraints, especially where there are many private abstractors and polluters, and where low paid government officials are charged with controlling the activities of rich and politically powerful industrialists.

Institutional capacity can also be related to the notion of integrity. This refers to, firstly, the institutional separation of water supply and regulatory functions. This is increasingly being seen as indispensable for effective water management, but is still uncommon in the developing world. Secondly, integrity relates to the degree of institutional fragmentation within the water sector. Where, for example, groundwater and surface water, and abstraction and discharge management, are dealt with separately, piecemeal and uncoordinated decision-making may result. This may increase the threat of degradation by decreasing the ability to recognise causes and manage consequences.

Box 2 Comparing management options

Pollutant control and demand management options can be compared in a number of different ways. Important evaluation criteria include:

Efficacy

- Impact on groundwater abstraction and pollutant loads - quantity and quality effects.
- Location of demand and load changes in relation to local hydrogeological conditions (e.g. aquifer vulnerability), abstraction points, and different water uses and users.
- Time lag between introduction of a measure and its effect. Some measures will bring improvements in groundwater quality sooner than others. In the short-medium term, it may be necessary to address the impacts of groundwater degradation (e.g. through treatment), before measures to control contaminant load take effect.

Costs and benefits

- Costs and benefits of alternative options. The key issue here is whether the benefits of pollution control, or treatment, outweigh its costs. Benefits (e.g. to health) may be difficult to measure, and centralised treatment may not be an option where unregulated, private groundwater abstraction is significant.

Equity

- Distribution of costs and benefits. Where do costs and benefits fall, in terms of polluters, different water users and uses, and between present and future generations? If groundwater degradation proceeds unchecked, the eventual 'losers' may be future generations forced to pay for more costly out-of-town supplies.

Political and public acceptability

- policies that are acceptable to the parties affected have better prospects of being implemented than those likely to encounter vigorous resistance. Factors affecting acceptability include: severity of the problem, and the level of uncertainty over aquifer conditions, rates of change and causal factors and agents; and the distribution and timing of costs and benefits, especially where benefits are long term and political time horizons short (see above).

Administrative feasibility

- Operating a policy must be within the capacity of the government agency or department involved. This implies the ability to monitor and ***enforce compliance*** with controls.

Drawing up a problem-management matrix

A further way of identifying management needs and possible policy options is to draw up a 'problem matrix'. An illustration is provided in Table 1 below, showing how one problem (poor water quality in shallow household wells) can be 'unpacked' to draw out underlying causes, and then analysed in terms of the management requirements for tackling it.

Working through matrices such as this can be useful for clarifying cause-effect relationships, though these can be quite complicated as problems typically have multiple causes (as in the illustration above).

Table 1 Illustration of problem matrix

Matrix of problems, issues and management needs					
Problem	**Evidence/Indicators**	**Cause(s)**	**Relative importance**	**Groundwater management needs**	**Policy interventions**
• Inadequate groundwater quality - private domestic boreholes tapping shallow aquifer	• Use of shallow groundwater by households as sole source of supply in some areas • Water quality indicators at a few sites • Some evidence of water-related health problems; water user survey revealed widespread dissatisfaction with quality • Some (high income) households installing treatment devices	• Growth in polluting industries in major industrial zones, especially chemical; water polluting industries subsidised • Some industrial zones located in sensitive recharge areas • Existing pollution control legislation ambiguous; lax monitoring and enforcement of controls; difficult for state agencies to control state polluters which generate big tax revenues • Absence of incentives to conserve water, and therefore recycle and/ or reuse wastewater; old, inefficient and water intensive industrial technologies	• Little historical evidence, but current indicators suggest for some households, in some areas, shallow groundwater is the only source of potable supply. This makes current action to address problem imperative	• Define source protection zones for control of contaminant loads • Reduce contaminant loads in selected industrial - recharge areas where groundwater used by households	• Redraft pollution control legislation • Monitor and enforce existing abstraction and pollution controls • Establish independent regulatory agency • Encourage adoption of clean technologies through low interest loans for new equipment • Provide alternative supplies for groundwater-dependent households

Strengths and weaknesses of the approach

It is important to emphasise that the DSS does not provide all the answers in terms of its assessment of groundwater contamination potential. Rather, it provides a first-pass summary of contamination threat, based on a limited set of data and certain simplifying assumptions. Data needs and assumptions have been made as transparent as possible so that constraints are known to users, but also to allow the system to be developed and refined further. Some key strengths and weaknesses are listed:

Strengths

- Can be used as both a diagnostic and predictive tool, to help characterise existing problems and to assess future ones, respectively.
- Has been developed with complementary data collection and urban profiling tools.
- Can be used by non-specialists, and by those without access to a computer
- Uses relatively simple and easily obtained data on urban activities and aquifer type.
- Can be used in different urban settings with comparable results.
- Can be easily modified or developed, as data needs and assumptions are transparent.

Weaknesses

- In its current form, the DSS does not include data on solid waste disposal, or groundwater abstraction. Both can have a significant influence on contaminant load and contaminant migration, respectively. In addition, the DSS does not include data on waste treatment methods. As these are likely to vary within and between different activities, the PC-based DSS defaults to a precautionary ‘no treatment’ setting.
- The DSS does not include spatial data, for example on aquifer vulnerability and urban activities, nor does it include data on the size/importance of different activities. Instead, the assessment of contamination threat is based on the simple presence or absence of different activities.
- The DSS supports decision-making by characterising problems, rather than providing guidance on how to deal with them. A brief summary of possible DSS outcomes and management strategies is provided, but this does not form part of the current DSS.