4-1 Civil EIAM UNIT-3

CHAPTER 3

Prediction and Assessment of Impacts on Soil and Ground Water Environment

3.1 Introduction

Almost every type of action or project can produce changes on the surroundings of the land. Some actions and projects will have direct effect, while others may induce changes or have secondary impacts. The assessment of potential land-use impacts should be comprehensive covering characteristics of the project.

3.2 Soils and Groundwater

The integrity of soils and groundwater can be altered by a variety of physical disturbances, including the addition/removal of soil and/or water, compaction of soil, changes in use of land or ground cover, changes in water hydrology, changes in climate (temperature, rainfall, wind), and the addition or removal of substances or heat (for example, discharge of effluents into groundwater, discharge of effluents or disposal of waste onto land, leaching of contaminants into groundwater, changes in quality of surface water, and deposition of air pollutants on land). The effects of these vary from first order effects of leaching into soil and groundwater to changes in groundwater regime, soil structure (including erosion and subsidence), soil quality or temperature, and groundwater quality or temperature. A summary of these effects is presented in Fig. 3.1.

3.3 Methodology for the Prediction and Assessment of Impacts on Soil and Groundwater

To provide a basis for addressing soil and/or groundwater environment impacts, a model is suggested, which connects seven activities or steps for planning and conducting impact studies. Fig. 3.2. In analyzing environmental impacts, both objective and subjective judgments should be taken into consideration. Objective judgments are defined as "those, which involve or use facts that are observable or verifiable especially by scientific methods and which do not depend on personal reflections, feelings, or prejudices "subjective judgments are those which are made on the basis of values, feelings and beliefs". In the context of the environment the objective judgment describes the impact where-as subjective judgment describes how people feel about the 'fact'.

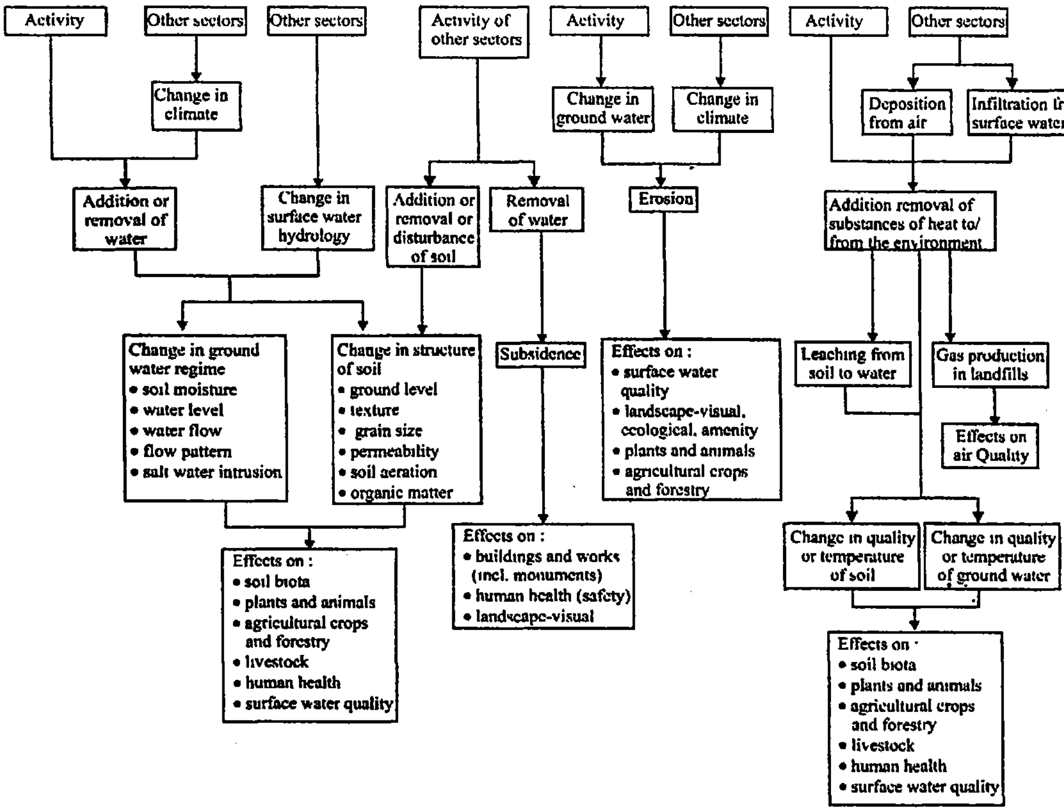

Fig. 3.1 Soil and groundwater effects.

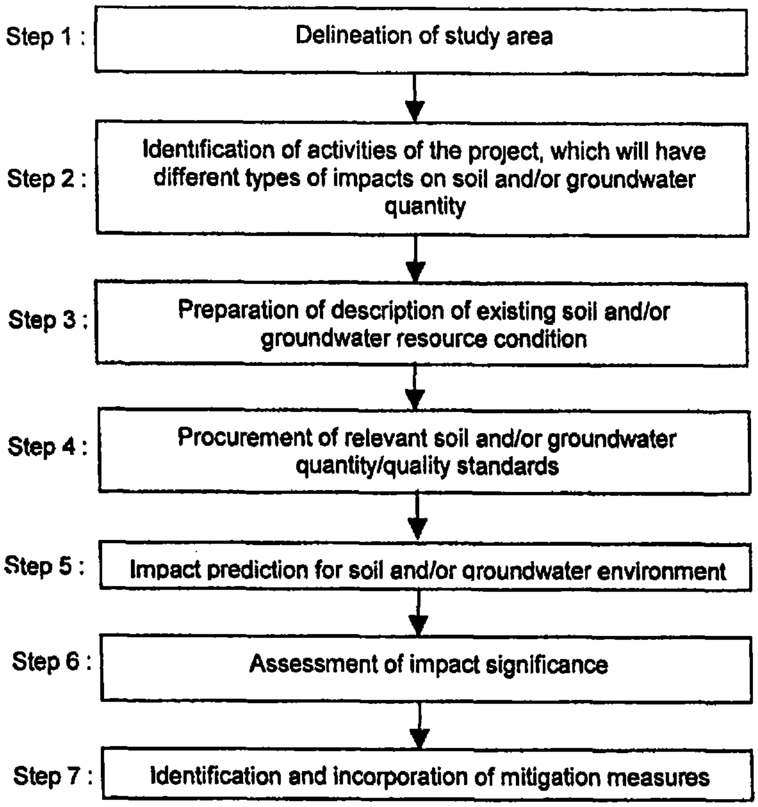

Fig. 3.2 Systematic approach for the study of impacts on soil and ground water.

3.3.1 Delineation of Study Area

The delineation of the study area for impact assessment will be very specific based on presence of potential impacts. The study area should reflect the full reach of possible effects within the particular impact discipline that is being considered.

The proposed or future land-use map along with committed land-use policies, zoning, and development projects should be included in the study area.

The map should clearly distinguish between developed and undeveloped land. Categories shown on land-use map, should be

- Residential
- Commercial and industrial
- Institutional and parks or recreation
- Non-urban mixed

The map could include further divisions, such as separate commercial and industrial activity centers and public vacant lands. The categories to be used will depend largely on the type of project or action being evaluated, the characteristics of the local land area, and the geographic extent of the affected study area.

3.3.2 Identification of Activities, Which Will Have Different Types of Impacts on Soil and/or Groundwater Quantity – Quality

Direct Land-Use Impacts on Land

1. *Landforms :* Unique or important physical features that have special importance, as recreational educational or scientific interests may be present in the project area. They may be unique locally or unique in a larger area. Examples are rock out crops, river gorges, sandy beaches, and lagoons. Such features may also influence local climate.
2. *Soil profile :* The soil profile is related to the chemical and physical nature of the soil and the prevailing climate and therefore has a direct bearing on land capability for agricultural or other purpose. Erosion is the principal process which may alter the soil profile and it can have a direct effect on existing or potential land use, and an indirect effect, through siltation on water quality, fishing, land use downstream.
3. *Soil composition :* The chemical and mineral composition of the soil influences its engineering and agricultural capability. Changes in soil composition can occur either by, subtraction e.g., acid or alkali leaching or by addition e.g., cation exchange extraction, nitrogen fixation.
4. *Slope stability :* Rock slopes are inherently stable. The environmental effects of slope instability are similar to those for erosion. The scale of the effects are larger in this case.
5. *Seismicity :* Stress, vibration, due to explosions and deep well injection operations can have an effect on the stress-strain equilibria on fault planes. Renewed or increased activity can have major environmental effects for the project site.
6. *Subsidence and compaction :* Subsidence and compaction occur naturally but generally as a gradual and almost imperceptible process. The process can be accelerated however, by underground excavation, vibration or loading. The major effect is on land capability but drainage, groundwater behavior and landscape could also be affected.
7. *Flood plains Swamps :* Flood plains and swamps are an important part of the drainage pattern as they admit peak flows into the drainage system. Reclaimation on natural flood plains or swamps may result in flooding and siltation of other areas during peak flow. Major engineering of a drainage system may either decrease the amount of agricultural land available or may destroy wetland habitats of fish, birds etc.
8. *Land use :* The existing land use and the compatibility with existing or planned use of adjacent land are important components of the environment. Careful site selection is the principal means of controlling them but many mitigating or abatement measures may also be available.
9. *Mineral or engineering resources:* The occurrence of mineral or engineering resources is of strategic and economic importance. Loss of such resources either through wasteful use or through development incompatible with subsequent mining or quarrying proposal can result in long-term economic or social impacts on the community.

10. *Buffer zones:* Buffer zones are spaces which provide natural environmental protection from drainage by external events They are usually vegetated, depending on the purpose and can provide wind breaks, erosion control, sediment traps, wild life shelter, sound insulation and visual screening.

Some projects or actions, by their very nature, have direct and obvious impacts of land use by physically destroying or clearing land and implementing a new use. Here are some examples of this kind of direct land-use revision:

(a) A highway project with a 300 right-of-way width converts whatever the existing land use is to a transportation land- use within that right-of-way width.
(b) A dam constructed to create a reservoir for water supply and recreational use directly converts the previous land use to recreational use.
(c) A regional park constructed on land previously used as pasture directly changes the number of acres of the park into a different use.
(d) A city block of low-income housing structures is demolished to construct a shopping mall, directly converting that land to commercial use.

Examination of Existing and Future Planned Land-Use for Delineating Study Area

The first step is to get the necessary information on existing development trends, planned development projects, and especially the goals and objectives of land-use plans and policies. These existing and proposed committed projects and policies are then factored into the no-build alternative. The result is a definition of future development intensity and policy without the proposed project. The impact of the proposed project is the difference between these future conditions (no - build) and the future conditions with implementation of the proposed project or action (build). There may also be substantive differences among the various build alternatives being considered.

An initial activity is co-ordination with the regional planning organization and with the local planning officials and zoning agencies. This early contact is valuable to

- Determine the existing and planned land- use and zoning for the area of the proposed project,
- Identify any particular problem,
- Identify goals for land- use and economic development
- Initiate continued review and co-ordination throughout the project study phase.

Depending on the expected magnitude of impact of the various activities of the project, the population growth, the study area should be delineated.

Environmental Impacts on soil and ground water- A typical Example : Road Construction Project

Impacts and Setting

Soil is an important component of the natural environment, and is a primary medium for many biological and human activities, including agriculture. Its protection in relation to road development deserves considerable attention.

In the road itself, in borrow pits, or around rivers and streams, there are many places where damage might occur. Losses can be considerable for the road agency and others. This includes farmers losing crops and land, fishers losing income because of sedimentation in rivers and lakes, and road users being delayed when road embankments or structures collapse. The costs of correcting these problems are often many times greater than the costs of simple preventive measures.

Loss of Productive Soil

The most immediate and obvious effect of road development on soil is the elimination of the productive capacity of the soil covered by roads. Unfortunately, the best sites for road development (flat and stable) also tend to be ideal for agriculture. The narrow, linear character of roads makes the impact of lost land seem minimal, but when the width of the right-of- way is multiplied by its length, the total area of land removed from production becomes much more significant. Soil productivity can also be reduced significantly as a result of compaction with heavy machinery during construction.

Erosion

When natural conditions are modified by the construction of a road, it marks the start of a race between the appearance of erosion and the growth of vegetation. Disturbance during construction can upset the delicate balance between stabilizing factors, such as vegetation, and others which seek to destabilize, such as running water. In some cases erosion might result in cumulative impacts far beyond the road itself, affecting slopes, streams, rivers, and dams at some distance from the initial impact.

Destabilization of Slopes

Slope stability can be upset by the creation of road cuts or embankments. Excessive steepness of cut slopes, deficiency of drainage, modification of water flows, and excessive slope loading can result in landslides Fig. 3.3. Some soils, such as shale and "quick clays", are known for being difficult to drain and particularly unstable.

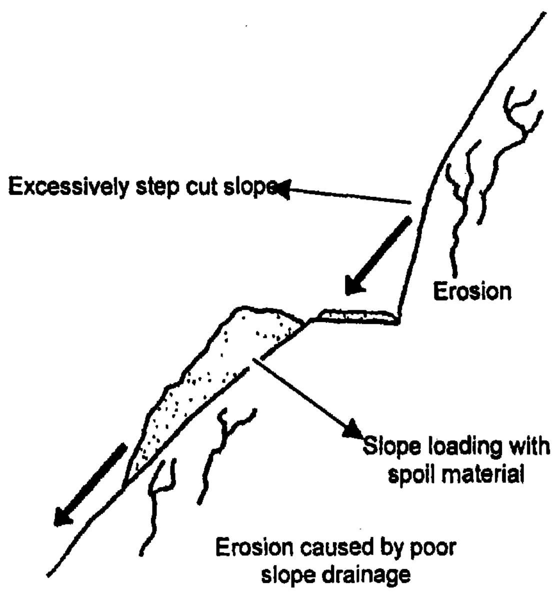

Fig. 3.3 Destabilization of slopes.

Side Tipping of Spoil Materials

Spoil material from road cuttings can kill vegetation and add to erosion and slope stability problems. Large amounts of spoil can be generated during construction in mountainous terrain. Sometimes it is difficult to design for balances between cut and fill volumes of earth at each location, and haulage to disposal sites may be expensive. This creates a need for environmental management of tipped material.

Water Flow Diversions

Diversion of natural surface water flows is often inevitable in road projects. Diversion results in water flowing where it normally would flow.

Engineering Measures

In many cases, vegetation alone may not be enough to prevent erosive damage to slopes, and various engineering measures may be needed to complement or replace it (Fig. 3.4). The use of slope retaining techniques may be necessary when

- Slopes are unstable because they are too high and steep;
- Climatic conditions are such that establishment of vegetation is slow or impossible;
- There is a risk of internal erosion or localized rupture because of drainage difficulties; and
- It is necessary to decrease the amount of earthwork because the road width is limited.

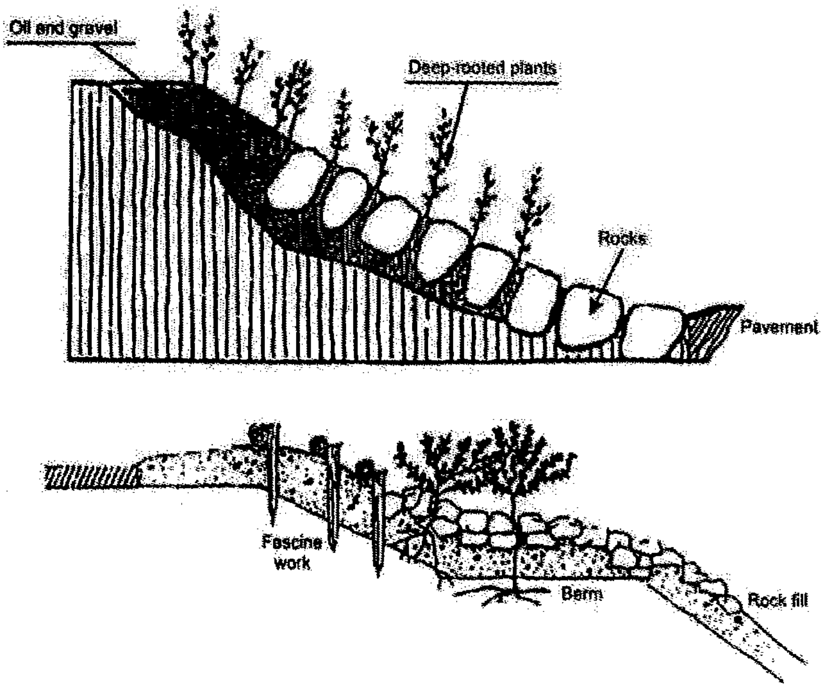

Fig. 3.4 Examples of combined techniques for slope protection.

Well established engineering measures for slope protection include :

- Intercepting ditches at the tops and bottoms of slopes. Gutters and spillways are used to control the flow of water down a slope;
- Terraced or stepped slopes to reduce the steepness of a slope. A berm (or riseberm) is the level section between slope faces;
- Riprap, or rock material embedded in a slope face, sometimes combined with planting;
- Retaining structures, such as gabions (rectangular wire baskets of rocks), cribs (interlocking grid of wood or concrete beams, filled with earth or rock), or other types of wooden barricades and grid work, usually battered back against the slope;
- Retaining walls, more substantial engineering structures able to resist bending, and with a footing designed to withstand pressures at the base of the slope;
- Reinforced earth, embankment walls built up as the earth fill is placed, with anchors compacted into the fill material; and
- Shotcreting and geotextiles, generally more expensive options with specific applications

Preliminary Procedure for General Projects

An appropriate initial activity when analyzing a proposed project or activity is to consider what types of soil and/or geological disturbances might be associated with the construction and/or operational phases of the proposed project, and what quantities of potential soil contaminants are expected to occur.

"Impact trees" or "networks" can be used to delineate potential impacts on the soil and geological environments.

Regarding the identification of potential soil pollutants, a list of the materials to be utilized during the project and those materials which will require disposal could be developed. Examples of materials that may result in soil contamination include fuels and oils, bituminous products, insecticides, fertilizers, chemicals, and solid and liquid wastes. As an initial step, a simple checklist of the types and quantities of chemicals associated with each activity could be prepared and utilized. Transport and effects information on key chemicals could also be included. It may also be appropriate to consider the quality of leachates from waste materials disposed on land.

Environmental problems in land conservation in the following can be analysed using systems analysis techniques:

1. The degradation of soil fertility due to increase in concentration of sodium, caused by water logging and application of chemical fertilisers.
2. Physical loss of soil through accelerated erosion due to the action of water and wind .
3. Impact of the conversion of good farm lands into reservoirs and dwelling areas.

Groundwater – Quantity and Quality Impacts

The consideration of groundwater quantity and quality impacts consist of identifying the types and quantities of groundwater pollutants and/or groundwater quantity changes anticipated to be associated with the construction and operational phases of the proposed project. This activity should also be performed for any alternatives to the project or proposed plan programs.

Numerous types of projects could have detrimental impacts on the soil or geological environment, or both Table 3.1 & 3.2.

Table 3.1 Effects of developmental activities on five classic factors for soil formation.

·Factors of soil Formation	Type of effect	Nature of effect
Climate	Beneficial	Adding water by irrigation; rainmaking by seeding clouds, removing water by drainage, diverting winds, etc.,
	Detrimental	Subjecting soil to excessive insolation to extended frost action, to wind etc
Organisms	Beneficial	Introducing and controlling populations of plants and animation adding organic matter including 'nightsoil', loosening soil by ploughing to admit more oxygen; following, removing pathogenic organisms adding radioactive substances.
	Detrimental	Removing plants and animals; reducing organic matter content of soil through burning ploughing, over-grazing, harvesting, etc, adding or fostering pathogenic organisms; adding radioactive substances
Topography	Beneficial	Checking erosion through surface roughening, land forming and structure – building
	Detrimental	Causing subsidence by drainage of wetlands and by mining; accelerating erosion; excavating
Parent material	Beneficial	Adding mineral fertilizers; accumulating shells and bones; accumulating ash, locally; removing excess amounts of substances such as salts.
	Detrimental	Removing, through harvest, more plant and animal nutrients than are replaced, adding materials in amounts toxic to plants or animals, altering soil constituents in a way to depress plant growth.
Time	Beneficial	Rejuvenating the soil through adding of fresh parent material or through exposure of local parent material by soil erosion; reclaiming land from under water.
	Detrimental	Degrading the soil by accelerated removal of nutrients from soil and vegetation cover; burying soil under Solid fill or water.

Source : Goudie (3)

Table 3.2 Examples of human-induced effects on soil characteristics.

Soil factor	Beneficial change	Neutral change	Adverse change
Soil chemistry	Mineral fertilizers (increased fertility) Adding trace elements Desalinize (irrigation) Increase oxidation (aeration)	Altering exchangeable ion balance Altering pH (lime) Alter via vegetation change	Chemical imbalance Toxic herbicides and herbicides Salinize Over–removal of nutrients
Soil physics	Induce crumb structure (lime and grass) Maintain texture (organic manure or conditioner) Deep plowing, after soil moisture (irrigation of drainage)	Alter structure (plowing, harrowing) Alter soil microclimate (mulches, shelter belts, heating, albedo change)	Compaction/plow pan (poor structure) Adverse structure due to chemical changes (salts) Removal perennial vegetation
Soil organisms	Organic manure Increase pH Drain/moisten Aerate	After vegetation and soil microclimate	Remove vegetation and plow (less and microorganisms Pathogens Toxic chemicals
Time (rate of change)	Rejuvenate (deep plowing adding new soil, reclaiming land)		

Examples of Types of Projects and Associated Impacts Include

1. Land subsidence which can occur as a result of over- pumping of ground-water resources or oil gas resources in a given geographical area or which can occur as a result of surface or sub-surface mining activities associated with mineral extraction.
2. The impacts associated with the identification and usage of construction material for major projects, with such material coming from identified burrow areas. (There may be changes in local surface water hydraulics and erosional patterns as a result of construction material.).
3. Construction practices in general can create some concerns related to the potential for increased soil erosion in the construction area. This increase in soil erosion could lead to specific mitigation requirements, such as, the creation of sediment retention basins or the planting of rapidly growing vegetation.
4. Landslides, caused by inappropriate slope stability, which can occur as a result of over development on particular soil types within the areas having certain topographic features.
5. The potential concerns associated with constructing and operating nuclear power plants, chemical production plants, waste–disposal facilities. and/or large storage tank facilities in areas characterized by seismic instability and excessive earthquake potential. (This can influence siting decisions and decisions associated with construction and operation activities.)
6. Strip–mining operations for coal extraction, or other mineral resource extraction wherein the land surface is to restore the original landscape, possibly in some type of alternative topographic arrangement.
7. The construction of jetties along coastal areas in order to control beach erosion and littoral drift.
8. Projects which may create acid rain in localized area, with the acid rain, in turn, having an impact on soil chemistry and, potentially, on sub-surface groundwater resources.
9. Projects wherein the site characteristics in terms of soil and geological features are incorporated as components in the selection process examples of such site–selection oriented projects, sludge–disposal projects, and upland locations for dredged–material disposal.
10. Projects that involve developments along the coastal areas wherein coastal erosion problems may either be increased by the project, or may influence the proposed project itself. Examples of such projects include the coastal marins and associated secondary developments, industrial development projects with associated port and boat mooring facilities, and projects, which involve the development of ports and harbours.

11. The construction and operation of surface water reservoir projects, with the purposes of the projects ranging from the single purposes of providing flood control to multiple purposes, including hydro-electric power development, provision of water supply, and so on. There are two key environmental concerns relative to soil and geological issues, the first is related to sedimentation within the reservoir and the provision of appropriate sediment – storage capacity in terms of the project lifetime; the second is related the potential effects of such surface water reservoir projects on the subsurface environment, including changes in soil, ground water, and geological features that lie underneath the water pool of the reservoir.
12. Projects associated with permits for grazing leases or other leases related to agricultural uses, where the subsequent grazing or agricultural developments could lead to changes in soil characteristics such as erosion patterns and soil chemistry. Examples of such changes are in Table 3.2.
13. The potential effects of soil characteristics on buried pipelines, with examples including the potential loss of the physical integrity of the pipeline as a result of acid or corroding soils.

3.3.3 Description of Existing Soil and/or Ground water Resources Soil Characteristics

Background Information on the Soil Environment

Soil Characteristics

Soil characteristics in a given geographical area at a given point of time are a function of both natural influences and human activities.

The soil and geological environments are typically associated with the physical and chemical environment.

For example, the habitat types and associated vegetation found in an area will be a function of the soil characteristics. Additionally, cultural resources may be related to soil characteristics or possibly, to unique geological features in an area.

The relationship between shallow, alluvial aquifers and the flow of surface streams and rivers may need to be explored. Table 3.3 summarizes the principal anthropogenic activities, which can cause ground- water pollution.

In describing quantity and quality, specific indicator parameters can be utilized. For example, the following represent some of the information, which could be compiled, and the issues, which could be addressed, are :

1. Descriptions should be assembled on groundwater systems in the study area, indicating whether they are confined or unconfined, with the obvious pollution relevance being that unconfined groundwater systems tend to be more susceptible to groundwater contamination.
2. Of particular importance would be the description of karsts aquifer systems, since these areas can exhibit unique and rapid groundwater flow patterns.
3. Many areas are characterized by the presence of multiple groundwater systems; accordingly, it would be appropriate to describe those geographical areas characterized by multiple aquifer systems.

4. If information exists on the quantitative aspects of the groundwater resource in terms of potentially useable supplies, which could be extracted, it should be summarized.
5. Information should be summarized on the uses of groundwater within the study area, with a more detailed study of this subject to be conducted later.
6. A description of the relationships between local groundwater systems and surface streams, lakes, estuaries, or coastal areas may be important, since mutual quantitative or qualitative influences can occur.
7. Groundwater pollution vulnerability is associated with the question whether or not the project area is in a recharge zone for a given groundwater system. This should be determined because there is greater pollution potential in the recharge zone. (It should be noted that for confined aquifer systems the recharge area may be located a was long way from the actual segment of the groundwater system being used form purposes of water supply.)
8. Depth of groundwater is a fundamental parameter which could be identified, with the pertinent issue that greater the depth of groundwater, the greater the degree of natural protection.
9. Unsaturated - zone permeability should be described. Here, the "unsaturated zone" refers to that segment of the subsurface environment, which is between the land surface and the water table of an unconfined aquifer system. The unsaturated zone permeability can influence the attenuation of contaminants as they move away from a source of pollution and toward the groundwater system.
10. Aquifer transmissivity should be described. This parameter represents information on the water carrying capacity of the ground water system.
11. Any existing data on groundwater quality should be summarized. If no such data exists, it may be necessary to appropriately plan and conduct a groundwater-monitoring program. In some unique cases, the quality data may need to be described in terms of aquatic ecosystems. For example, several threatened or endangered aquatic species have been found in springs associated with the Edwards aquifer in central Texas.

Unique Soil or Groundwater Problems

Many geographical areas exhibit special or unique problems that should be addressed in the description of baseline conditions for the soil or groundwater resources in the study area. Examples of these problems include saline seeps, groundwater supplies relative to existing bacteriological or other quality constituents, poor natural quality, and the presence of hazardous waste sites. Dryland farming practices involving irrigation often lead to salt accumulation in surface soils and shallow unconfined aquifers.

Pollution Sources and Groundwater Users

It is appropriate to consider which other potential and actual sources of soil and/or groundwater pollution may exist in the study area, and also to consider current and potential future usage of the groundwater resource for purposes of water supply techniques. Quantitative impact prediction is typically associated with the use of look – alike, or analogous projects for which knowledge and information are available, and/or the utilization of relevant case studies.

3.3.4 Procurement of Relevant Soil and / or Groundwater Quantity - Quantity Standards

Land-use restrictions, soil quality standards, soil reclamation requirements, and groundwater quantity – quality standards, regulations, or policies are examples of institutional measures, which can be used to determine impact significance and required mitigation measures. Thus, to determine the specific requirements for a given project area will require contacting appropriate governmental agencies with jurisdiction.

The primary sources of information needed for step 3 (Figure 3.2) will be pertinent to the governmental agencies, namely, Central government, State government and/or local agencies. In addition, international environmental agencies may have information pertinent to this step.

3.3.5 Impact Prediction

The prediction of the impacts of a project – activity on the soil and/or ground - water environment(s), or conversely, the potential influence of the environment(s) on a proposed project, can be approached from three perspectives.

1. Qualitative
2. Simple quantitative, and
3. Specific quantitative

In general, efforts should be made to quantify the anticipated impacts; however, in many cases this will be impossible and reliance must be given to qualitative trend and through the spreading of excess sub-soil over the right – of – way during clean-up. In general, the mixing of sub-soil with topsoil will have an adverse impact in soil fertility and soil structure. The severity of the impact will depend on the nature of the sub-soil.

Qualitative Approaches-Groundwater Impacts

A qualitative approach for groundwater – impact prediction involves the fundamental sub-surface environmental processes. The fundamental processes in the sub-surface environment can be examined relative to their hydrodynamic (physical), biotic (chemical), aspects. Table 3.3 summarizes processes, which may affect constituents of groundwater.

Table 3.3 Possible sources of ground water contamination.

Category I	Sources designed to discharge substances
Subsurface percolation (e.g., septic tanks and cesspools)	
Injection wells	
Hazardous waste	
Non-hazardous waste (e.g., brine disposal and drainage)	
Non-waste (e.g., enhanced recovery, artificial recharge, solution mining, and in-situ mining)	
Land application	
Wastewater (e.g., spray irrigation)	
Wastewater by – products (e.g., sludge)	
Hazardous waste	
Non-hazardous waste	

Table 3.3 *Contd...*

Category II – Sources designed to store, treat, and/or dispose of substances; discharge through unplanned release

- Landfills
  - Industrial hazardous waste
  - Industrial non-hazardous waste
  - Municipal sanitary
  - Open dumps, including illegal dumping (waste)
  - Residential (or local) disposal (waste)
  - Surface impoundments
    - Hazardous waste
    - Non-hazardous waste
  - Materials stockpiles (non-waste)
  - Graveyards
  - Animal burial
  - Aboveground storage tanks
    - Hazardous waste
    - Non-hazardous wate
  - Underground storage tanks
    - Hazardous waste
    - Non-hazardous waste
    - Non-waste
  - Containers
    - Hazardous waste
    - Non-hazardous waste
    - Non-waste
- Open burning and detonation sites
- Radioactive disposal sites

Category III – Sources designed to retain substances during transport or transmission

- Pipelines
  - Hazarous waste
  - Non-hazardous waste
  - Non-waste
- Materials transport and transfer operations
  - Hazardous and transfer operations
  - Non-hazardous waste
- Materials transport and transfer operations
  - Hazardous waste
  - Non-hazardous waste
  - Non-waste

Category IV – Sources discharging substances as consequence of other planned activities

- Irrigation practices (e.g., return flow)
- Pesticide applications
- Fertilizer applications
- Animal feeding operations
- Urban runoff

Table 3.3 *Contd*

Percolation of atmospheric pollutants	
Mining and mine drainage	
	Surface mine – related
	Underground mine – related
Category V – Sources providing conduit or inducing discharge through altered flow patterns	
Production wells	
	Oil (and gas) wells
	Geothermal and heat recovery wells
	Water supply wells
Other wells (non-waste)	
	Monitoring wells
	Exploration wells
Construction excavation	
Category VI – Naturally occurring sources whose discharge is created and/or exacerbated by human activity	
Ground water – surface water interactions	
Natural leaching	
Salt – water intrusion/brackish water upcoming (or intrusion of other poor – quality natural water)	

Source : Office of Technology Assessment, 1984, p. 45.

Groundwater

1. ***Water table :*** The water table elevation is an important contributory factor to engineering and agricultural land capability. It also affects the nature of habitats. A change in its seasonal fluctuation may result from a reduction in the natural recharge or from increased draw-off from the ground water system
2. ***Flow regime :*** The ground water flow regime, the direction and rate of flow may be altered by surface or under ground engineering, especially drainage works, by draw-off and by the penetration of cap rocks of confined aquifers, any such change can have an impact on other users of the ground water source
3. ***Water quality :*** Water quality is important for economic, ecological, aesthetic and recreational purposes. Changes in water quality may affect water treatment costs or ever deny some uses of the water. These changes can be chemical, biological or physical
4. ***Recharge :*** Impoundment, rearing or compaction of the ground surface and removal of vegetation can alter the recharge of the ground water system. Recharge should be considered together with water table, flow regime and water quality
5. ***Aquifer characteristics :*** Sometimes known as "Aquifer safe yield" these include all the physical parameters (porosity, permeability etc), which govern the ability of aquifer, provide water for human use. Over pruning or waste injection can cause a decrease in the "Aquifer safe yield"
6. ***Existing use :*** The uses of ground water system must be for engineered domestic, industrial and agricultural supply or natural agricultural and ecological dependence on the ground water system