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THE PLACE OF THE EARTH SCIENTISTS IN URBAN PLANNING AND DEVELOPMENT

by

E.G. WILSON

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THE PLACE OF THE EARTH SCIENTISTS IN URBAN PLANNING AND DEVELOPMENT

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E.G. WILSON

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ABSTRACT

Planners and engineers engaged in urban planning and development require information on the environment concerning pollution, natural resources, the engineering characteristics of geological materials, and natural hazards, and much of this information can be obtained only from Earth scientists. The need for such information represents a market that the Earth scientist should endeavour to supply. The planner and engineer are concerned with planning strategy on a regional scale, urban design at area scale, and project construction. It follows that the Earth scientist must carry out his investigations at three different scales, each directly applicable to the particular stage of development, and within a time frame dictated by the decision-making processes. For his product to be relevant to the planner and engineer, he must produce documents directly applicable to particular problems; instead of a treatise on the geotechnical aspects of soil and rock instability in an area, he should present a map accurately showing the areas of unstable materials classified according to types of instability and degrees of risk, and annotated with geotechnical data relevant to the various types of land use and to the planning of remedial measures. The planner and engineer on their side have the responsibility of ensuring that the Earth scientist is given notice of their requirement in advance so that his contribution is timely and can be applied to the decision-making process. To promote the application of Earth science to urban planning and development, the Earth scientist must convince the planners and engineers of the relevance of his contributions to their problems; he must also convince the Earth-science hierarchy that this work is a necessary and appropriate function of Earth science in modern society.

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INTRODUCTION

The term'Earth scientist'generally is taken to refer to geologists, geophysicists, and geochemists, and should also include in this context soil scientists. Urban planning and development is traditionally the realm of the planner and engineer; the planner designs the urban environment and the engineer builds it. They need information about the natural systems they have to work with, and call on a wide range of specialists including the Earth scientist, generally the geologist, to provide part of this information; he calls on other Earth scientists to contribute where it is necessary, and hopefully provides his contribution in a form relevant to the tasks of the planner and engineer. Many other sciences have contributions to make either directly, or indirectly; however, this paper looks mainly at the Earth sciences. Generally the geologist is not involved until he is called in, by which time the need for information is pressing, anf his reaction often is: 'I wish someone had told me about this job two years ago'; however, he goes ahead and does the best he can in the time available. I regard this need for Earth-science information as a 'market' for our services; we therefore should examine the 'market' and then look at the 'product' required to satisfy it. We cannot stop there as it is also necessary to demonstrate its application to the market and promote its sale and acceptance.

MARKET

We will first look at the needs of the planner; his raw material is the environment, it may be urban or rural. If it is urban and he is concerned with redevelopment, he starts with an environment containing the debris of civilization created by previous generations, which may obscure the face of the Earth beneath to a depth of a few metres. If it is rural the land surface is visible but its condition may be much changed from that which existed before man came on the scene. Examples of such changes are the encroachment of sand through the removal of vegetation; the depletion of groundwater through irrigation; and subsidence after the removal of minerals such as coal, and oil and gas. Contributions to the needs of the planner have not yet been fully recognized as a market for Earth science contribution.

The engineer is concerned with the raw materials, which are the earth and rock materials on which structures are founded, or of which they are built. The services of the engineering geologist in civil construction have been recognized by the engineer for many years, and are concerned with tunnels, dams, and foundations. The need of the engineer is a recognized and established market.

The planner requires information on the environment that he is to redesign, and the engineer requires information on the materials that he is reshape. The environment is an overworked word these days, but the process of urban development can be regarded as the modification of the existing environment to form a new environment that is as harmonious as we can make it with urban development. The history of past mistakes indicates that there are four major aspects of the environment that bear directly on either the quality of the new environment or the economics of its development. They are:

1. Pollution
2. Natural resources
3. Engineering characteristics of geological materials
4. Natural hazards.

Table 1 lists some of the basic data relevant to Earth-science assessment of these four aspects; it also lists the interpretative maps and reports derived from the data that are required by planners and engineers to carry out their tasks. Table 1 is not meant to be all-embracing, and may have omitted some aspects that might be considered relevant. Some of the data required for Earth-science assessment apply to more than one of the four major aspects of environmental interest, and many of the listed interpretative maps and reports also bear on more than one field of interest to planners and engineers. Thus, Earth-science contribution may be relevant to a number of planning and engineering tasks, so that to achieve the widest application of such works there must be co-ordination by a range of Earth scientists and scientists in other fields, with planners and engineers.

Table 2 summarizes Table 1 and can be used as a checklist for Earth-science input to urban development studies.

The Earth-science contributions include data derived from outside the fields of Earth-science interest; branches of engineering are able to provide data and contribute to the assessment of many tasks listed in Tables 1 and 2; in some subjects the main body of expertise lies with the engineers because of a lack of interest by Earth-scientists. It should be recognized that engineers have contributions to make that complement those of the Earth scientists, particularly in the fields of hydrology, and soil and rock mechanics.

No discussion of the market would be complete without reference to the economic gains that accrue from such work, and the many instances of costly failures or partial construction failures through lack of geological work in the past. Urban planning without geological advice has resulted in development on valuable deposits of engineering materials, such as sand, gravel, and clay, thus preventing their exploitation; in areas where subsidence as a result of the exploitation of minerals, water, and petroleum has induced failure in the structures above; and on inadequate foundation materials.

I hope that at this stage we have established that there is a market for interpretative maps and reports based on Earth-science assessment of data from many sources, and that it is accepted that they are relevant to the tasks of planners and engineers.

PRODUCT

The decision-making process should consider urban development in three stages:

1. Planning strategy on the regional scale
2. Planning on the urban design scale
3. Feasibility, design, and construction on the project-construction scale.

The Earth scientist must supply a product relevant to the particular stage of urban development, and his tasks appropriate to each stage are set out in Table 3. The only difference between the stages is their timing and the scale of each study; the content will still bear on the four main environmental aspects, namely pollution, natural resources, engineering characteristics of geological materials, and natural hazards, and the particular tasks can be selected from Table 2; only the detail of their treatment will vary in emphasis and interpretation.

The Earth scientist must ensure that his products are available when they are required by the planners and engineers; if he fails to meet their deadlines, then he has wasted his time. The time available for him to undertake his work and submit a report will, understandably, be limited, but the planners and engineers who commission his services must allow him sufficient time to make a satisfactory contribution. In addition, a responsible approach to staffing and organization for this work is essential.

The scales of investigation range from the broad regional scale of planning strategy - 1:250 000 to 1:100 000 - through that of urban design - 1:25 000 to 1:10 000 - to the project scales of 1:2500 to 1:1000, or even larger for critical data such as bore logs.

Traditionally the Earth scientist presents his results in order to provide an understanding of his science for fellow scientists. The Earth-scientist in urban development knows that his basic data has an application to the problems that face the planner and engineer but, to penetrate the market effectively, he must present his results as an assessment that is relevant to the market, and not as a scientific treatise written for other scientists. The Earth scientist must appreciate the needs of the planner; this can be gained only through discussions with members of the planning staff. Maps and reports should have interpretative legends and tabular and graphical presentations that illustrate the relative suitability of areas for particular aspects of development and outline the constraints imposed on the planner. They will not only delineate areas and provide a brief qualitative assessment, but must be supported by a document that defines all the relevant data on which the assessment is based; this may form an appendix or a separate report. In too many studies the detailed basic data are not recorded because they are not directly relevant to the planner and engineer; therefore, such work cannot be critically examined nor can it serve as a reference to other Earth scientists. The final tasks of the Earth scientist then, should be to write technical reports in which all the basic data are compiled (Table 3).

Stage 1

The first task of the planner is to develop a planning strategy within which to create an urban environment with everything that is needed to support it: communications and transport facilities, including corridors to other areas, an airport, and possibly shipping facilities; water supply and sewerage systems; recreational areas such as national parks and wilderness areas; and areas suitable for suburbs and town centre. The planner will also aim to protect the natural and economic resources of the area. At this stage he does not concentrate on a small area, but on the region within which development is planned; he needs an assessment of all data relevant to the four basic aspects of environmental interest in the whole region, and he requires guidance concerning the environmental impact of development. To assess all the options available to him when planning an urban environment that will support, for example, 300 000 people, the planner will require a comprehensive knowledge of the environment within an area of at least 30 000 km^2.

The provision of this information has been called environmental geology, a fashionable term these days but not so easy to define. I would define it as any aspect of geology that requires study in order to understand the geological processes that affect the stability of the environment. The natural environment is not necessarily stable: wind and water erosion, land surface instability, earthquakes and volcanism are all part of the natural environment. Man's activities are additional factors that may retard or accelerate natural processes, or introduce other changes, and are referred to as environmental impact.

Stage 1 currently has the least Earth-science input, because few regional studies have been commissioned far enough in advance to provide a comprehensive service to planning strategy, it is further discussed below. The Bureau of Mineral Resources is contributing to investigations at the regional level for new urban areas around Canberra, Australia.

Stage 2

The second stage is directly related to urban design for a particular area; mapping is on a larger scale, preferably the one at which the planner is constructing his design. This stage provides more detailed geological data directly relevant to the options of design, and must be ready in time to serve the design process; it is more oriented to engineering and constructional difficulties and to remedial action in areas with special constraints identified in the regional study. The scale of the mapping, between 1:25 000 and 1:10 000 will require additional fieldwork, drilling of soil and weathered rock, and investigation of groundwater problems. This stage should identify all the problems that will be encountered and contain information appropriate to the assessment of environmental impact. Close contact must be maintained with the planner; discussions help to establish the priorities of development: for example, the need to investigate drainage problems, and the construction of remedial works, may mean that a rearrangement of the priorities for development has to be made.

Stage 3

The third stage is geological work associated with the feasibility, design, and construction phases of specific engineering projects, and is the traditional role of the engineering geologist - although a very recent tradition. I will not dwell on this accepted service except to point out that the success of this service depends directly on the integration of geology into the planning and engineering processes, and this seems to be best achieved by assigning a geologist to the engineering team engaged in feasibility and design studies and construction.

SALE AND APPLICATION OF EARTH SCIENCE CONTRIBUTIONS

According to Pollard and Moore (1969) Earth science has little significance in urban planning and development. Of 26 professional disciplines they list as having a bearing on urban planning, soil scientists and geologists (representing Earth science as a whole) have a major role in only two of the 55 studies they list for investigation, and a minor role in 10 others. They considered that the Earth sciences should primarily fulfil an engineering geological role - as a service during engineering construction. To some extent this attitude still prevails among engineers; however, the Earth sciences must accept some blame for the fact that their work has not been recognized and applied. A view has been held by some eminent scientists that the scientist who is engaged in the pursuit of his science in any field other than pure science is a rather shabby character engaged in the prostitution of his art, and something of a skeleton in the science cupboard. In order to sell his product, the Earth scientist has to convince not only the planners and engineers of its relevance to their tasks but also the Earth science hierarchy that environmental and engineering Earth science is an appropriate and necessary function, and that the deployment of staff to this task is as important as the allocation of staff to the more traditional area of mineral resources.

We now return to discuss the Earth-science contribution at the regional level. The only prerequisite that is required for a regional investigation is a decision to undertake urban development in a particular area; yet there have been few comprehensive Earth-science contributions to investigations at the regional level. Where they have been undertaken, the time to carry out the task has been too short, and the availability of Earth scientists restricted by pressure of other work. A fear exists in the policy field that preplanning investigations would initiate a spate of speculation on the one hand, and engender a genuine apprehension among landholders on the other; thus some decisions have been taken on urban development without first endeavouring to provide comprehensive regional Earth-science data. The belief that investigations associated with the preparation of a regional study would encourage such fear and speculation is ill-founded; the investigations for such a region would cover an area of about 30 000 km^2, and mapping would be at scales of between 1:250 000 and 1:100 000; I feel sure that a well conducted study at these scales would give little encouragement to speculation.

It is the function of planners and engineers to see that the time allowed for investigations for all stages of development is adequate. A time of two years before any decisions are taken would be the minimum for regional studies, and one year for areal studies and construction services. Another pertinent observation relating to the later stages is that, if a sound regional study is available, then subsequent investigations, which do not involve such large areas, could be more easily carried out by organizations with fewer resources, and could lead to the more effective use of the services of consultants or alternatively to the attachment of Earth scientists to the staffs of development organizations for the provision of Earth-science input at the working level in close contact with the planners and constructional engineers. It is only through mutual recognition of each other's problems and capabilities that the Earth-science input will become accepted and applied in an appropriate manner.

CONCLUSIONS

The Earth scientist has a place in urban planning and development only if his contributions are oriented to the four major environmental aspects of urban development, namely pollution, natural resources, engineering characteristics of geological materials, and natural hazards. His contributions should be specifically produced to serve each stage of the development process, and will only achieve full recognition when they are presented in a form that is understandable to the planner and engineer, and directly applicable to their specific tasks; to achieve this, sufficient lead time is required to ensure that they are comprehensive.

REFERENCE

POLLARD, W.S., & MOORE, D.W., 1969 - The state of the art of planning.

PROC. AM. SOC. CIVIL ENG., 95 (J. urban planning Devel. Div.), in UPI, April 1969, Pap. 6516, 27-42.

TABLE 1

EARTH-SCIENCE CONTRIBUTIONS TO URBAN STUDIES

MAJOR ASPECTS OF ENVIRONMENTAL INTEREST	DATA REQUIRED FOR EARTH-SCIENCE ASSESSMENT	INTERPRETATIVE MAPS FOR REPORTS REQUIRED FOR PLANNERS AND ENGINEERS
POLLUTION (a) Water	1. Character of liquid waste from all sources.	1. Sources of liquid pollution.
	2. Drainage characteristics and flood records.	2. Infiltration properties of soil and rock.
	3. Surface water quantity and quality, including turbidity.	3. Potential for erosion of soil and rock.
	4. Groundwater quality, quantity, and aquifer potential.	4. Historical and potential landslip areas.
	5. Permeability and chemical characteristics of soil and rock.	5. Groundwater effluent zones in soil and rock.
	6. Movement of surface and groundwater.	6. Characteristics of surface runoff and flood potential.
	7. Movement of water, and its chemical and biological nature in tidal zones.	7. Potential for groundwater pollution.
	8. Nature of estuarine sedimentation including chemical character.	8. Rock and soil suitable for effluent disposal.
		9. Groundwater potentiometric surface.
		10. Pollution potential of tidal-zone water and sediments.
(b) Land	1. Character of industrial, household, and sewage waste (including landfill, coal and mineral waste dumps, and manufacturing waste).	1. Location of all waste dumps and their potential for pollution.
	2. Permeability and chemical nature of soil and rock.	2. Rock and soil suitable for landfill.
	3. Groundwater potentiometric surface.	3. Zones of leachate movement in groundwater.
	4. Nature of all leachates from dumps.	4. Leachate effluent areas.

TABLE 2.

EARTH-SCIENCE ASSESSMENT AND CONTRIBUTION TO URBAN DEVELOPMENT

DATA REQUIRED FOR EARTH-SCIENCE ASSESSMENT.

1. Nature of liquid waste from all sources.
2. Nature of solid wastes.
3. Character of leachates.
4. Drainage characteristics, turbidity and flood records.
5. Surface and groundwater hydrology.
6. Chemical characteristics of surface and groundwater.
7. Groundwater potentiometric surface.
8. Movement of water in tidal zones, and its chemical and biological nature.
9. Geology of unconsolidated and poorly consolidated deposits.
10. Nature of estuarine sediments and their chemical characteristics.
11. Foreshore and offshore topographic and geological mapping.
12. Nature and distribution of soils.
13. Geology of consolidated materials.
14. Mineral deposits and economic geology.
15. Geotechnical properties of soil and rock.
16. Geomorphology and geomorphic history.
17. Structural geology.
18. Earthquake epicentres.
19. Comprehensive mining and petroleum exploitation records.

INTERPRETATIVE MAPS AND REPORTS REQUIRED FOR PLANNERS AND ENGINEERS.

1. Sources of liquid pollution, and their future potential.
2. Locations of all waste dumps, and their pollution assessment.
3. Groundwater effluent areas, and seasonal variation of the potentiometric surface.
4. Potential for groundwater pollution.
5. Geological materials suitable for effluent disposal.
6. Geologic materials suitable for landfill.
7. Zones of leachate pollution in groundwate
8. Leachate effluent areas.
9. Runoff characteristics and flood potential.
10. Geological materials susceptible to erosion.
11. Pollution potential of tidal-zone water and inshore sediments.
12. Surface water resources.
13. Groundwater resources.
14. Geological materials and their geotechnical properties for engineering.
15. Engineering resources of stream and river beds and adjacent offshore areas.
16. Potential for urban agriculture and horticulture.
17. Landslips and landslip deposits, and areas of landslip potential.
18. Ease of excavation of geological material
19. Rock engineering properties and variation with condition of weathering.
20. Assessment of slope stability of geological materials.
21. Earthquake risk.
22. Tsunami risk.
23. Geological materials susceptible to subsidence.
24. Land subsidence risk from mineral, petroleum, and groundwater exploitation.
25. Areas containing exploitable reserves of minerals, petroleum, and groundwater.
26. Potential for shore erosion.
27. Potential for flood erosion.

NATURAL RESOURCES	1. Surface and groundwater hydrology. 2. Chemical characteristics of surface and ground-water. 3. Geology of consolidated and unconsolidated materials. 4. Nature and distribution of soils. 5. Mineral deposits and economic geology. 6. Marine geology.	1. Surface water resources. 2. Groundwater resources. 3. Mineral resourees. 4. Engineering materials resources and their geo-technical properties. 5. Potential for urban agriculture and horticulture. 6. Resources of stream and river bed materials and adjacent offshore areas.
ENGINEERING CHARACTERISTICS	1. Geology of consolidated and unconsolidated materials. 2. Groundwater hydrology and potentiometric surface. 3. Chemical characteristics of groundwater. 4. Nature and distribution of soils. 5. Geotechnical character-istics of soil and rock. 6. Geomorphology and geo-morphic history. 7. Marine geology. 8. Structural geology.	1. Materials of low bearing pressure. 2. Suction potential of foundation materials. 3. Historical and potential landslip areas. 4. Ease of excavation of rock and soil. 5. Geotechnical properties of unconsolidated and poorly consolidated materials. 6. Geotechnical properties of rock in all stages of weathering. 7. Potentiometric surface. 8. Assessment of stability for soil and rock excavations.
NATURAL HAZARDS	1. Earthquake epicentres. 2. Structural geology. 3. Geology of consolidated and unconsolidated materials. 4. Nature and distribution of soils. 5. Comprehensive mining and petroleum exploitation records. 6. Foreshore and offshore geological and topographic mapping. 7. Drainage characteristics and flood records.	1. Potential landslip areas. 2. Earthquake risk. 3. Land subsidence risk from historical and future mineral, petroleum, and groundwater exploitation. 4. Tsunami risk. 5. Flood risk. 6. Shore erosion and flood erosion potential.

TABLE 3: PLANNING SCHEDULE AND EARTH SCIENTISTS TASKS IN URBAN DEVELOPMENT.

Initiation Body	Key Events	Planning Action	Earth Scientists Tasks.
Government Stage 1	Decision to undertake urban development at a particular location.	1. Commission regional environmental study. 2. Set up regional planning body.	1. Compile geoscience data at regional scale (1:100 000 - 1:250 000). 2. Carry on regional fieldwork and gather geotechnical data. 3. Prepare regional environmental study as an interpretative report. 4. Commence regional technical report.
Regional Planning Body Stage 2.	Access to interpretative report from regional environmental study.	1. Plan broad design for development. 2. Allot priorities for areal development. 3. Define land policy and take appropriate administrative action. 4. Commission areal environmental studies.	1. Compile geoscience data at areal scale(1:10 000 - 1:25 000). 2. Carry out areal fieldwork and gather geotechnical data. 3. Prepare areal environmental studies as interpretative reports. 4. Complete regional technical reports. 5. Commence areal technical reports.
Regional Planning Body Stage 3A	Access to interpretative data from areal environmental studies.	1. Plan area designs in detail. 2. Allot project priorities for construction. 3. Initiate project feasibility studies.	1. Carry out geoscience investigations for feasibility studies and prepare reports. 2. Complete areal technical reports.
Construction Authorities Stage 3B	Authorization to design and construct projects.	1. Commission design studies. 2. Undertake construction.	1. Carry out geoscience investigations for design studies. 2. Compile all geoscience data gathered during construction. 3. Prepare project completion reports (geoscience). 4. Compile geoscience map series, a continning task as development proceeds.