表－b　浅井戸掘削コストの例

COST ESTIMATE OF 6"/4" SHALLOW TUBEWELL WITH 15 METER HOUSING, 15 METER SLOTTED PIPE AND TOTAR DEPTH 50 METER. (as of March, 1991)

1.	Mobilization and Site Preparation	NRs. 10,000
2.	Drilling Cost (including labour)	NRs. 25,000
3.	Pipes and Fittings	NRs. 35,000
4.	Development and Test	NRs. 10,000
5.	Consumable Goods	NRs. 5,000
	Total	NRs. 85,000
	Contingency 5%	NRs. 4,250
	Grand Total	NRs. 89,250

Source ; Ground Water Resources Development Project, Kathmandu, Nepal

2．調査実施上の留意点

(1) 本案件は深井戸開発に対する協力要請である。ネパールに於ける地下水開発が浅井戸開発から次のステップへと進んだ状況にあることを示している。ＩＤＡ融資によるバイラワ・ルンビニプロジェクトを見れば深井戸利用による灌漑は、浅井戸に比べれば井戸１ヶ所当たりの受益地が大きく、懸念されている揚水量についても経済的に十分引き合うだけの量が得られ、維持管理がし易い等メリットが大きい。効率の良い井戸開発が示されたことになる。

効率を求める井戸開発が推進されるようになった背景には電力供給事情が良くなった等いろいろあるが特に大きな理由としては、食糧需要の増加に見合うだけの農業生産の増大と生産性の増加を図ることが緊急の課題となっていることが挙げられる。

ネパールでは平野部のみならず丘陵地から山岳地に至るまで、中には山頂に至るまで開墾し、水田や畑が造成されている。それらの田畑は狭小で、水資源に乏しく生産性は極めて低い。このような山岳、丘陵地域に灌漑用水を供給し生産量の増加と農民の定住化を図ってきたが、期待通りの成果は得られていない。このためネパールの穀倉地帯であるテライ平野の中、灌漑用水が不足または皆無ではあるが生産性向上の可能性の高い地域に於いて優先的に水資源開発を行い、生産性向上を早急に達成することを目指している。前述のように大規模な表流水開発がやゝ行き詰まりを見せているため、水開発の手段としてより一層効率の良い深井戸開発が求められていると考えられる。

本調査のベースをなすネパールの農業事情の変化、農業振興策の詳細等については十分に把握されていない。また第７次長期経済計画以降の計画が公表されていないため長期計画に於けるテライ平野の農業振興策、地下水開発の位置づけ等についても明確にはされていない。経済計画、農業政策等の調査も含めることにより今後のネパールの農業に対する支援の方向が明らかになって来るものと考えられる。

(2) ネパールの水資源開発政策に於ける地下水開発の位置づけは極めて高いことは前述の通りＤＯＩから聞き取った。農業用水の有無に拘らず開発された農地では農業生産の向上のために灌漑用水を欠かすことは出来ない。地下水開発の可能性を調べたＵＮＤＰのレポートは土地利用の観点から調査区域を区分し、既存の地質調査結果を前提にして地下水開発の可能性を調査したものであって、水理地質学的な観点から地下水開発の可能性を検討したものではない。今回の調査は地域が限定されはするものの水理地質学的観点から十分調べ今後の地下水開発に有効なものとなるようにすべきである。

(3) バイラワ・ルンビニプロジェクトでは150m～200m程の深さまで掘削している。この深さの井戸を深井戸と呼んでいるが、地質学的に言うところの深層地下水利用の深井戸か否かははっきりしていない。地下水の賦存量の推定、地下水補給のメカニズムの解明、今後の利用計画の検討、管理計画の作成等に影響を及ぼすものと考えられるので今回の調査により地質学的にみて深層地下水を利用する深井戸か単に深い浅井戸かも明確になることが期待される。

(4) 本調査は、当面、地下水資源の評価の段階ではあるが、農業水資源開発計画の策定は地下水調査の実績に即して行われるものであり、ＤＯＩの計画部門との協調及び低コスト、あるいは集約的投資モデルの採用について配慮するとともにテライの地下水資源の開発として支援すべき主要な開発モデルが次のようなものである点に配慮しつつ調査する必要がある。

1）かんがいの「最後」の姿として、あるいは表流水計画の樹立より重要な初めての段階としての、天水地域における浅井戸開発

2）かんがい受益を全面的に増加するための、既存のかんがい計画の水不足の範囲内での浅井戸開発

3）主として「大規模事業」モデルに基づく、天水地域における深井戸開発。バイラワ・ルンビニ深井戸事業が、この区分での最も直接的な投資機会に相当する。

4）表流水の供給を増大するための大規模かんがい事業の深井戸開発

また、地下水調査の実績に即した開発計画策定に向けて、次のような点についても留意すべきである。

1）大きな表流水計画が実施できる以前の、急速な食糧生産を得るための手段としての井戸開発であること。

2）既存事業等のかんがい管理改善のためのプログラムとの組合せが望まれること。

3）「大規模事業」モデルに基づく深井戸事業の可能性の検討。

4）年間の水の供給をめざした事業の検討、あるいはモンスーンタイプの作付パターンを可能にするのに必要な補給水を供給するための事業の検討。

(5) ネパールの地下水開発についてはこれまでも日本の協力を含めて国際機関、２国間による援助を通じて進められてきた。これらの協力によりテライ平野のほぼ全域に於いて何らかの形で調査が進められ、相当数の井戸掘削も行われてきた。調査データも相当に蓄積されているもの

と思われるがその殆どは浅井戸に関するものである。浅井戸に関する指針はＪＩＣＡ専門家として派遣された相場瑞夫氏（当時農林水産省勤務）作成のもの（資料－13））が使われてきた。

今回の調査をきっかけとしてＪＩＣＡ協力により新たに深井戸開発指針が作成されることが期待される。

付　属　資　料

付属資料 1.　実施細則（S/W）

SCOPE OF WORK
FOR
THE MASTER PLAN STUDY
ON
THE TERAI GROUNDWATER RESOURCES EVALUATION
AND
DEVELOPMENT PROJECT FOR IRRIGATION
IN
THE KINGDOM OF NEPAL

AGREED UPON BETWEEN
DEPARTMENT OF IRRIGATION
MINISTRY OF WATER RESOURCES
AND
JAPAN INTERNATIONAL COOPERATION AGENCY

KATHMANDU, MARCH 26, 1991

Mr. M. D. Karki
Director General,
Department of Irrigation,
Ministry of Water Resources,
His Majesty's Government
of Nepal

Mr. Yasunobu MATOBA
Leader,
Preliminary Survey Team,
Japan International
Cooperation Agency

I. INTRODUCTION

In response to the request of His Majesty's Government of Nepal (hereinafter referred to as "HMGN"), the Government of Japan has decided to implement the Master Plan Study for the Terai Groundwater Resources Evaluation and Development Project for Irrigation (hereinafter referred to as "the Study"), in accordance with the relevant laws and regulations in force in Japan.

The Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, will undertake the Study, in close cooperation with the authorities concerned of HMGN.

The Department of Irrigation, Ministry of Water Resources (hereinafter referred to as "DOI") shall act as counterpart agency to the JICA Study Team and also as coordinating body in relation with other governmental and non- governmental organization concerned for the smooth implementation of theStudy.

The present document sets forth the Scope of Work with regard to the Study.

II. OBJECTIVES OF THE STUDY

1. To formulate a groundwater development master plan under the Groundwater Resources Evaluation and Development Project for Irrigation in a selected District in the Terai plain, and

2. To carry out technology transfer to the Nepalese counterpart personnel in the course of the Study.

III. OUTLINE OF THE STUDY

1. Study Area

The Study covers following three (3) Districts in the Terai plain.

1) Banke District including a part of the Bardia District on the left bank of the Babai River,

2) Mahottari District, and

3) Jhapa District excluding the Kankai Irrigation Project area.

2. Scope of the Study

In order to achieve the above objectives, the Study will consist of two phases and will cover the following :

1)Phase I

1)-1 To collect and review existing data and information and to carry out field survey and investigation in the three Districts in view of topography, meteorology, hydrology, geology, soil, hydrogeology, groundwater resources, agriculture, irrigation system(surface water and groundwater), and existing irrigation projects and water resources development plans,

1)-2 To evaluate groundwater resources for irrigation,

1)-3 To identify the groundwater irrigation potential and to formulate technical and management concepts for groundwater irrigation, and

1)-4 To select a most prospective District with the highest potential for deep tubewell development for irrigation.

2)Phase II

2)-1 To carry out hydrogeological survey, geophysical investigations, construction of observation wells, monitoring of groundwater resources, and assessment and evaluation of groundwater resources in a representative area in the selected District,

2)-2 To formulate a groundwater monitoring network plan in the

representative area, and

2)-3 To formulate a groundwater development and management plan in the representative area,

2)-4 To formulate a groundwater development master plan under the Groundwater Resources Evaluation and Development Project for Irrigation in the selected District. The Master Plan will include substancial items, such as

-Comprehensive evaluation of the groundwater resources,

-Guidelines for developing groundwater resources for irrigation,

-Data base of hydrogeologic and hydrometeorological information, and

-Guidelines for operating groundwater monitoring network.

IV. WORK SCHEDULE

The Study will be executed in accordance with the attached tentative work schedule.

V. REPORTS

JICA shall prepare and submit following reports in English to HMGN.

(1) Inception Report

Twenty (20) copies at the commencement of the Study.

(2) Progress Report (I)

Twenty (20) copies at the end of the field work in the Phase I study.

(3) Interim Report

Twenty (20) copies at the end of the Phase I study.

(4) Progress Report (II)

Twenty (20) copies at the end of the second field work in the Phase II study.

(5) Progress Report (III)

Twenty (20) copies at the end of the fourth field work in the Phase II study.

(6) Draft Final Report

Twenty (20) copies at the end of the Phase II study.
HMGN provides JICA with its comments on the Draft Final Report within one (1) month after receipt of the Draft Final Report.

(7) Final Report

Fifty (50) copies within two (2) months after receiving HMGN's comments on the Draft Final Report.

VI. UNDERTAKING OF HMGN

1. To facilitate smooth conduct of the Study, HMGN shall take necessary measures;

(1) to secure the safety of the Japanese study team,

(2) to permit the members of the Japanese study team to enter, leave and sojourn in the Kingdom of Nepal for the duration of their assignment therein, and exempt them from alien registration requirements and consular fees,

(3) to exempt the members of the Japanese study team from taxes, duties, fees and any other charges on equipment, machinery and other materials brought into the Kingdom of Nepal for the conduct of the

Study,

(4) to exempt the members of the Japanese study team from income tax and charges of any kind imposed on or in connection with any emoluments or allowances paid to the members of the Japanese study team for their services in connection with the implementation of the Study,

(5) to provide necessary facilities to the Japanese study team for the remittance as well as utilization of the funds introduced into the Kingdom of Nepal from Japan in connection with the implementation of the Study,

(6) to secure permission for entry into private properties or restricted areas for the conduct of the Study as and when necessity arises,

(7) to secure permission for the Japanese study team to take all data and documents related to the Study including photographs and maps out of the Kingdom of Nepal to Japan,

(8) to provide medical services as needed. Its expense will be chargeable on the members of the Japanese study team.

2. HMGN shall bear claims, if any arises, against the members of the Japanese study team, resulting from, occuring in the course of, or otherwise connected with the discharge of their duties in the implementation of the Study, except when such claims arise from gross negligence or wilful misconduct on the part of the members of the Japanese study team.

3. DOI shall, at its own expense, provide the Japanese study team with the followings, in cooperation with other authorities concerned:

1) Available data and information related to the Study,

2) Counterpart personnel,

3) Suitable office with necessary furniture in Kathmandu and project sites,

4) Credentials or identification cards,

5) Permission for use of radio communication (Walkie Talkie), and

6) Arrangement for procuring fuel for vehicles and boring machines.

VII. UNDERTAKING OF JICA

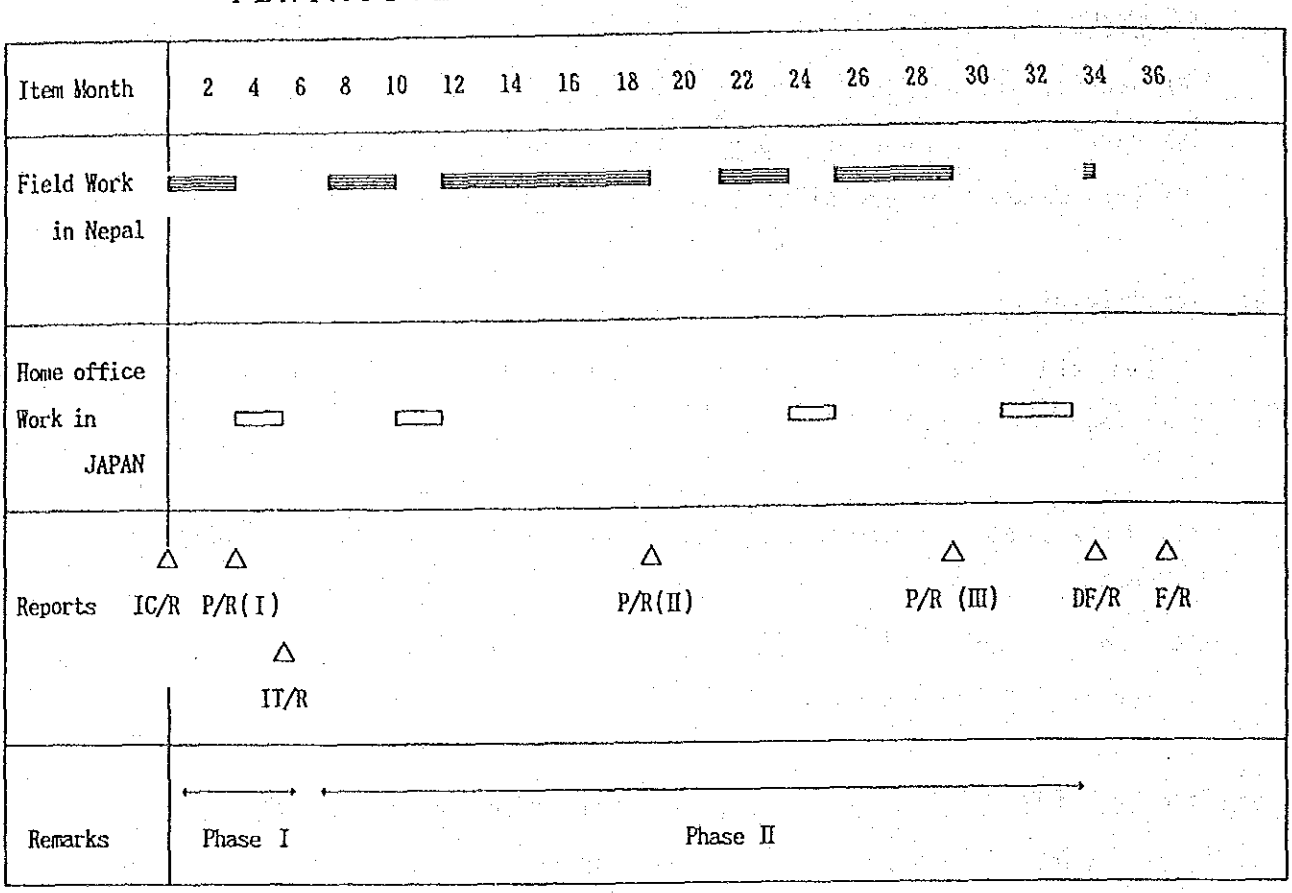
For the conduct of the Study, JICA shall take the following measures;

1. To dispatch study teams, at its own expense, to the Kingdom of Nepal, and
2. To conduct technology transfer to the Nepalese counterpart personnel in the course of the Study.

VIII. JICA and DOI will consult with each other in respect of any other matter that is not agreed upon in this document and may arise from or in connection with the Study.

APPENDIX

TENTATIVE SCHEDULE



(Remarks) IC/R : Inception Report P/R : Progress Report
IT/R : Interim Report DF/R : Draft Final Report
F/R : Final Report

: Field Work
: Home Office Work

付属資料2. 協議議事録（M/M）

MINUTES OF MEETING
ON
SCOPE OF WORK
FOR
THE MASTER PLAN STUDY
ON
THE TERAI GROUNDWATER RESOURCES EVALUATION
AND
DEVELOPMENT PROJECT FOR IRRIGATION
IN
THE KINGDOM OF NEPAL

The Preliminary Survey Team (hereinafter referred to as "the Team") organized by Japan International Cooperation Agency (hereinafter referred to as "JICA"), and headed by Mr. Yasunobu MATOBA, visited the Kingdom of Nepal from March 18 to March 27, 1991 for the purpose of discussing and confirming the Scope of Work for the Master Plan Study on The Terai Groundwater Resources Evaluation and Development Project for Irrigation in the Kingdom of Nepal (hereinafter referred to as "the Study").

The Team had a series of discussions with the officials concerned of the Department of Irrigation, Ministry of Water Resources of His Majesty's Government of Nepal (hereinafter referred to as "DOI") on the Scope of Work for the Study. The list of participants in a series of meetings is shown in the attached paper.

As a result of the discussions, the Team and the DOI agreed on the Scope of Work for the Study.

The following are the main issues discussed and agreed upon by both sides in relation to the Scope of Work for the Study.

1. The office for the Japanese study team should be equipped with electricity, city water, and telephone.

2. The DOI shall, at its own expense, prepare vehicles for the Nepalese counterpart personnel.

3. The DOI requested that the following equipment necessary for the Study be procured by JICA and be donated to the DOI after the termination of the Study. The Team promised to convey its request to the Government of Japan.
   a. Vehicles,
   b. Bore hole electric loggers,
   c. Groundwater level indicaters,
   d. Photocopy machines,
   e. Personal computers, and
   f. Portable kits for chemical analysis.

Kathmandu, March 26, 1991

Mr. M. D. Karki
Director General,
Department of Irrigation,
Ministry of Water Resources,
His Majesty's Government
of Nepal

Mr. Yasunobu MATOBA
Leader,
Preliminary Survey Team,
Japan International
Cooperation Agency

Attachment

LIST OF PARTICIPANTS

I. Nepalese Side

Ministry of Water Resources

Mr. M. D. Karki	Director General, Department of Irrigation (DOI)
Mr. Y. L. Vaidya	Deputy Director General, DOI
Mr. A. B. Thapa	Superintending Engineer, DOI
Mr. G. P. Chaturvedi	Project Manager, Groundwater Resources Development Project
Mr. S. R. Uprety	Divisional Geologist, DOI

II. Japanese Side

Preliminary Survey Team

Mr. Yasunobu Matoba	Leader
Mr. Takashige Ueta	Member
Mr. Akio Yamamoto	Member
Mr. Norio Matsuda	Member

付属資料3. 要　請　書(T/R)

MINISTRY OF FOREIGN AFFAIRS

His Majesty's Government of Nepal
Kathmandu

November 2, 1988.

NEA/72-2/GWREDP/ 993

The Ministry of Foreign Affairs, His Majesty's Government of Nepal presents its compliments to the Embassy of Japan in Kathmandu and has the honour to inform that His Majesty's Government requests the Government of Japan to provide technical co-operation and grant-in-aid for the Terai Groundwater Resources Evaluation and Development Project.

The Ministry of Foreign Affairs takes this opportunity to enclose herewith a copy of the "Project Proposal" for the Embassy's needful action.

The Ministry of Foreign Affairs avails itself of this opportunity to renew to the Embassy of Japan the assurances of its highest consideration.

The Embassy of Japan,
Kathmandu.

NOV. - 2. 1988

DRAFT

PROPOSAL FOR
THE TERAI GROUNDWATER RESOURCES EVALUATION AND DEVELOPMNT PROJECT

AUGUST, 1986 (REVISED)

GROUNDWATER RESOURCES DEVELOPMENT BOARD

BABARMAHAL, KATHMANDU.

TABLE OF CONTENTS

INTRODUCTION

As is well known the Terai farms the main seat of the agricultural sector of Nepal a sector on which the economy of Nepal is largly dependent. Deppite its centrality to the economy the gross domestic product of this sector has grown in the recent years at a rate smaller than the rate of growth of the non-agricultural sector. Nepal's poor economic performance (less than 2.4% GDP growth annually) during the Fifth Five-ye ar Plan (1975-1980) inspite of real increases in the level of investment could mainly be accounted by little increases in agricultural production. This situation could be remedied, the production of this sector expanded and its contribution to the National Economy increased by a greater application of production input and, in particular provision of irrigation water by construction of supply schemes which would make available dependable water supplies for wet season crops, predominantly paddy rice and would also make dry season cropping a profitable operation. The natural source of irrigation water supplies for the dry season cropping are the groundwater resources of the Terai which by proper management can be made available during the dry season when surface water is non existent or in-sufficient to enable to overcome the inbalance between the irrigation needs for two growing seasons, and the available water resources. It is expected that agricultural production can be increased considerably by providing irrigation water also in the dry season.

In keeping with the priority given to quick yielding investments, emphasis was put in the Fith Plan (1975-80) for the completion of ongoing irrigation schames and new investment in projects with short gestation periods and high returns, including groundwater development tubewells. In the Sixth Five Year Plan (1980-85) also groundwater irrigation development by tubewells has been emphasized. It is realised that groundwater development has to play a major role in the future in fulfilling the irrigation and water supply need of the terai.

Numerous investigations have proven without doubt that the Terai possess ample groundwater resources that can be extracted in a profitable way by means of tubewells of various depths capable of supplying at medium to high capacities. However the Terai extends over a large area and the investigations carried out at the Government initiative with and without foreign financial and technical assistance were naturally not intended to cover the whole Terai.

Furthermore, most of the investigations were oriented towards the immediate supply of groundwater and did not deal with the important aspect of the systematic evaluation of the ground water resources which is of utmost importance for all integrated development planning. It is true that resources evaluation was done within the scope of all feasibility studies conducted for the various irrigation projects in the Terai but these are few compared to the extension of the area.

It is the opinion of this department after having studied the present state of information concerning the groundwater resources of the Terai and having talks with the various professional consultants from the international organisations (CIDA, UNDP, IDA, ADB) that the systematic and overall appraisal of the Terai's groundwater resources should be initiated by the government, more specifically, by the personnel of the department of irrigation hydrology and meteorology in conjunction with the Groundwater Resources Development Board.

The present memorandum is a proposal for the carrying out of such an appraisal.

2. PROJECT OBJECTIVES

The objectives of the proposed Project may be divided into:

(a) Long range objectives:

1. To meet the demands for irrigation water in the Terai in order to increase agricultural production.
2. To make a groundwater unit proficient in the field of Resources Investigation and Evaluation and also in Groundwater Development Planning and Management. And

(b) Immediate objectives:

1. To conduct a comprehensive and systematic evaluation of the GroundWater resources of the Terai this to provide the data needed for the planning of the efficient development of this resource. This objective may be further subdevided as follows:

- to obtain information related to the hydrogeological conditions affecting the occurance of groundwater and the groundwater flow regime.
- the qualitative and quantitative determination of the recharge and discharge mechanisms of the existing shallow and deep aquifer including the subsurface inflow and out flows.
- to determine the present state of exploitation and quality of groundwater.
- to determine areas of priority with respect to ground water development possibilities.
- to establish guidelines for utilisation of groundwater in these areas.

2. To provide on the job and formal training for Government personnel in the relevant fields of groundwater investigation, development and management.

3. THE PROJECT AREA

General:

The Terai is the southern most geographic region of Nepal comprising gently sloping to almost flat plains at an elevation of 60 - 300 m above sea level. These plain form the northern part of the gangetic plain, to the north they are bordered by the Churia (Siwalik) hills. These plains extend for about 800 Km. all along the Indian border in the form of a strip

of 25-45 Km. width. The Terai plain accounts for about 15% of the total area (140,800 Sq.Km.) of the country. The Terai may geographically be devided into three sub regions:

(a) the eastern terai extending from Mechi to Narayani

(b) the western terai extending from Narayani to Karnali

(c) the far western terai extending from Karnali to Mahakali.

From an administrative point of view the terai is devided from west to east into 20 districts.

Climate:

The climate is sub tropical with an average annual rainfall ranging between nearly 2000 mm in the east down to about 1000 mm in the west. Precipitation occurs in the monsoon season between June and October.

River System:

The terai is crossed from north to south by a few large perenial rivers originating in the high Himalayas in the northern part of Nepal with sustained flow throughout the year and a few rivers which rise in the hilles and mountain areas in the central part of Nepal with large seasonal variations of discharge. Numerous small rivers rise in the Churia (Siwalik) hills. They are generally seasonal and cease to flow during the dry months.

Geology:

Sediments forming the Siwalik hills accumulated during tertiary time in an ancestral geologic environment simlar to the present. These sediments were subsequently uplifted and eroded at the end of the tertiary period forming the Siwalik hills. Alluvial sediments of tertiary age below the terai extend thousand of meter below the surface.

Geophysical surveys indicate that young alluvial sediments in the Terai may have a thickness of up to 1500 m. Logs of investigation wells indicate a thickness of atleast 450 m. Sediments beneath the Terai have accumulated alternately as alluvial and fluvial deposit by rivers flowing from the hills. Erosion, bed load and suspended load in these rivers are highly variable and so are their sediments where they emerge from the hills and deposit their load in response to lower gradient and distribution of flow.

The terai sediments adjacent to the hills are dominated by pebble boulder and gravel layers which become more extensive near emerging river systems. These so called Bhabar deposits have accumulated where stream gradient are steeper. The Bhabar deposites gradually change downstreams to sand & fine gravel through interbedding.

Sediments deposited by various sub depositional environments form aquifers that are lenticular, discontinously layered and interbeded. The aquifer layers are separated by clay, silt, and fine sand which from aquicludes of continous, discontinous interbedded and lenticular nature. The sequence of sediments can be correlated in a general way only.

Geo-Hydrology

Groundwater occurs in the Terai under Phreatic and under confined conditions. The dominance of Coarse material adjacent to the hills and river systems result in lesser resistence to vertical infiltration and Phreatic condition prevail in these areas. Areas to the south will be underlain by continous and discontinous clay and silt beds limiting vertical movement thus causing a gradual change into confined and even artesian conditions. Finer sediments predominate in the stratigraphic sequence along the southern part of the Terai and away from Perenial rivers. The aquifer system is fed directly from precipitation over the phreatic parts of the aquifer as well as form runoff from the Sivalik hills and form perenial rivers infiltrating into the coarse deposit in the Bhabar Zone and the upper Terai. Upper shallow aquifer are also fed directly by precipitation and infiltrating run off. The confined aquifers are fed by lateral groundwater flowing in the North to South direction. Groundwater is discharged from the phreatic aquifer in the north along a line to springs where the aquifer undergoes confinement,

also along river beds. Groundwater discharge from confined aquifers takes place as southward subsurface flow. There may also exist an upward component in places where the confining layers are not continous or not completely impermeable. Ground water studies indicate that the Terai aquifer system sustains wells capable of pumping from 150-500 m^3/hr from the deeper confined aquifers depending on location and about 20-50 m^3/hr from the shallow aquifer. Depth of the deep wells range from 100 - 200 m, shallow wells have depths of 30-60 m, Water table and piezometric heads in the southern Terai are a few meters below or above ground surface. In the northern Terai the water table may be found at depths reaching 20 m depending on the topography.

4. CONCEPTUAL APPROACH

It should be pointed out from the start that the proposed project is very pronouncely oriented towards the planning and development of Groundwater resources. However this process of planning can proceed beyond the speculation and master planning stage only under the condition that the availability of the resources is demonstrated in a reasonably detailed and quantitative manner. The great extent of the Terai, the lack of professional personnel, equipment and budgetary means make the simultaneous evaluation of the Groundwater resources of the whole Terai impossible. The project will therefore proceed in stages by evaluating groundwater resources in district

after district according to priorities determined below by the Groundwater Resources Development Board. Some of the criteria to determine this priority rating may depend on existing agricultural development plans, on existing irrigation projects, on known hydrological conditions prevailing in the district and on existing or planned distribution of the electric power system.

In each district a comprehensive groundwater survey will be conducted. The final product of this study for each district will consist of the following for the whole district.

1. Description of Aquifer configuration.
2. List of existing wells & present Groundwater exploitation.
3. Detailed description of Groundwater Regime.
4. Determination of Groundwater available for exploitation.
5. Guide lines for Groundwater Development.
6. Data base of hydrogeologic information for the district.
7. Guide lines for operating a Groundwater monitoring network.

There will be made an effort to standardise the final report pertaining to Groundwater evaluation in order to facilitate the use of the information for planning purposes. Also a standard form of data base will be established. During the first stage of the project a systematic evaluation of all existing groundwater survey and data (Prefeasibility, feasibility and others) will be made. This study will make available to the planning authorities

the present state of knowledge on Groundwater availability in the Terai according to district. This evaluation will also be a starting point for the second stage of the project. The Groundwater resources evaluation study will include a drilling programme for exploration and observation wells.

It is foreseen that external help in the field of groundwater evaluation, development planning and management will be needed. This will also provide on the job training for the personnel of Groundwater Resources Development Board.

Proposed Priorities:

The proposed priorities by districts for the completion of the groundwater take into consideration that simultaneous work will be done in the eastern and western Terai and will be conducted in such a way as to facilitate the cooperation of investigation teams and drilling rigs in adjacent districts, and to facilitate logistics.

The following is the list of proposed priorities:

1. Kapilvastu
2. Banke
3. Kailali
4. Kanchanpur
5. Bardia
6. Dang-Deokhuri
7. Nawal Parasi
8. Khthmandu Valley
9. Muhottari

10. Sunsari
11. Morang
12. Jhapa
13. Chitwan
14. Dhanusha
15. Sarlahi
16. Siraha
17. Saptari
18. Bara
19. Parsa
20. Rautahat
21. Rupendehi.

There will be three activities in this project which deal with the whole terai and will thus be undertaken simultaneously for all the districts. These activities are concerned with the study and evaluation of existing reports, the establishing of a ground water monitoring network for the Terai & preparation of a centralised data base. As the establishing of a monitoring network involves the employment of professional personnel, the purchase of transportation means and establishing of offices, this activity will be conducted according to the following priorities determined according to the numbers of wells and piezometers at present existing in the various zones.

The following is a list of proposed priorities by zones for the establishing of monitoring network.

1. Lumbini (Rupendehi, Kapilvastu, Nawal parasi)
2. Seti-Mahakali-Bheri (Kailali, Kanchanpur, Bankeq Bardia)
3. Nara ani-Bagmati (Bara, Parsa, Rautahat, Chitwan, Kathmandu vally)
4. Rapti (Dang Deokhori)
5. Sagarmatha-Janakpur (Saptari, Siraha, Mahottari, Dhanusa, Sarlahi)
6. Kosi-Mechi (Sunsari, Morang, Jhapa)

The monitoring networks will be further developed and enlarged in each district as it is undergoing the hydrogeological investigation connected with the resource evaluation.

5. PROPOSED ACTIVITIES:

The groundwater resources evaluation study will be carried out in the various district consecutively in accordance with priorities established in section 4. If possible certain activities, after being carried out in the current priority district, will continue in the district with the following priority.

5.1 Compilation & study of existing hydrogeological information

Within the frame work of this activity the following will be accomplished.

- Organization of an archive for hydrogeological information in the Terai.
- Collection of all existing reports, maps, geological sections, hydrographs etc. relating to hydrogeology of

the Terai. For this purpose all relevant government ministries, local branches of consulting engineering firms and offices of international technical assistance and financing institution will be visited and relevant data copied or transferred to the central archive of Groundwater Resources Development Board.

- Study of existing reports, maps, hydrographs, geological sections.
- Preparation of first systematic evaluation of Groundwater availability according to district.
- Definition of information gaps.
- Deliniation of areas according to prospects of groundwater development.

5.2 Geological Study:

The geological study is intended to provide data necessary for obtaining a clear idea of the geological and geometrical configuration of the aquifer system. The occurance and distribution of permeable and impermeable or semipermeable formations, thickness of such formations, interconnections and continuity of the same. For this purpose following will be accomplished.

- Hydrological interpretation of areal photographs and topographical maps and geological maps to determine extension of aquifers, drainage pattern, extent of gravel fans, spring lines, old river channels, flood plains, river terraces, etc.

- Study of regional geology
- Study of existing well logs, lithological and electrical logs of shallow and deep wells.
- Preparation of geological cross section indicating aquiferous and nonaquiferous formations.
- Delineation of areas with higher thickness of aquiferous layers thus specially suited for exploitation drilling.
- Delineating of areas not suitable for exploitation drilling.
- Defining gaps in geological information.

5.3 Geo-electrical Investigations:

In order to fill the gaps in geological information exploratic drilling will have to be resorted to. However because of the high expenses of drilling a geo-electrical study of some area where deep bore holes exist for correlation will be conducted to determine aquifer thickness and nature. This study will consist of the following activities.

- Prepare a programme of geo-electrical soundings in sections in accordance with existing data for correlation.
- Conduct a geo-electrical survey.
- Make interpretation of survey to determine extend and thickness of coarse sediments, extent thickness and depth of production aquifers, thickness of impervious or semi pervious formations.
- Summary information of maps and sections of the geo-electric survey.

5.4 Drilling programme of exploration and observation wells:

In area where the geological information turns out to be insufficient for a full description of the aquifer configuration the drilling of exploration wells will be resorted to. The aim of these wells which will be small and large diameter wells is two fold. In the first place the objective of these wells will be to provide information concerning thickness and lithology of the subsurface and on the other hand to provide information as to the hydraulic properties of the aquiferous formations and to the suitability of a certain location to sustain pumping wells. For this purpose the large diameter exploration wells will be pumptested. In this frame work the following will be accomplished.

(It is assumed that about 20-25 exploration wells will be drilled in each district):

- Determination of sites for exploration drilling. This will be based on the study of existing geological and geoelectrical data.
- Design and technical specification for the drillings.
- Drilling and Drilling supervision.
- Conduct electrical log in the well (RES, SP, Gamma).
- Design well completion based on electrical log and formation samples.
- Develop and pump test large diameter exploration wells.

- Conduct hydrological tests in large diameter exploration wells.
- Levelling in of wells and determination of coordinates.
- Technical analysis of water sample (complete water analysis).
- Prepare well report (well log, well construction, result of pumping tests etc.

5.5 Hydrogeological Studies:

The hydrogeological studies are directed towards providing information of groundwater regime and availability:

- Preparation of key map (1:50,000) of project area showing all relevant data.
- Inventory and mapping of existing wells and estimation of present withdrawal of pumping and flowing wells.
- Establishing a network of Groundwater level monitoring for shallow and deep aquifer.
- Levelling in the wells in the network.
- Prepare groundwater level hydrographs for existing and new wells.
- Prepare groundwater contour maps for shallow and deep aquifer.
- Prepare map showing depth to water in shallow and deep aquifer.

- Study available data and river courses and define recharge & discharge areas & mechanisms, of shallow & deep aquifer.
- Conduct hydrological tests and together with existing data determine distribution of aquifer parameters in form of maps.
- Elaborate on correlation between river course and real distribution of transmissivity.
- Determine exploitable groundwater in storage.
- Sampling representative wells in shallow and deep aquifer.
- Complete analysis of samples to determine suitability for agricultural and domestic use.
- Prepare S.A.R. and E.C. maps.
- By consulting agricultural studies estimate conveyance losses and return flow from irrigation.
- Locate springs or seepage areas and estimate yearly discharge from aquifer.
- By comparison with hydrometeorological study prepare first estimate of groundwater balance.
- By analysing all results of study define distribution of groundwater available for exploitation.

5.6 Hydrometeorological Study:

It has to be kept in mind that a great part of the ground water resources of the Terai originate in run off entering the Terai from the north. By understanding the run off regime an insight will be gained also on the relation between natural replenishment and climatological factors like precipitation, evaporation temperature. Depending on available information a hydrometeorological study using computerised analysis will be initiated comprised of the following activities.

- Collecting daily and monthly data on rainfall in the surface catchments.
- Statistical analysis of data and selection of most representative stations for each basin.
- Collecting climatological data (temperature, humidity, radiation, winds and evaporation).
- Statistical analysis of climatological data.
- Collecting data on run off of surface water and springs.
- Verification of consistency and homogeneity of data.
- Stud the effect of various diversions and regulations by dams etc.
- Preparation of hydrological & hydrometeorological balances by means of discharge simulation & calibration of parameters.

- Estimation of aquifer recharge in correlation with seasonal groundwater level fluctuations and pumping.
- Elaborate on river aquifer interaction.

5.7 Groundwater development planning:

In this content it is understood than an analysis will be made of all the material collected and guide lines for groundwater development for short term and long term periods will be given. However all forecasts of interference will be preliminary extimates until more experience is gain from actual aquifer operation:

- Determine distribution of exploitable storage of shallow [illegible] aquifer
- Determine [illegible] sites for exploitation wells.
- Determine technical specification for appropriate exploitation well for zones in shallow and deep aquifers.
- Determine well spacing for well fields.
- Estimation of interference between pumping wells.
- Estimation of influence of prolonged pumping on regional water table or piezometric surface.
- Estimation of influence of prolonged pumping on artesian flow of wells.

5.8 Monitoring Network:

It is very important for the efficient development of Groundwater resources to be in posession of data related to the seasonal and long term trend of groundwater levels and of piezometric heads of the confined aquifers. Such information can be obtained only by systematically and regularly measuring in the field the items of interest. However it is in many cases superfluous to measure in all wells and a certain number of wells is selected to form the network of those to be regularly monitored. The selection of this network will be done in such a way that both the shallow and deep aquifers will be sufficiently covered. Withdrawal from wells and artesian flows will however have to be measured in all wells. The establishing of a monitoring network will thus consist of the following activities:

- Selection of a network of observation wells for the measurement of water levels in the shallow aquifer.
- Selection of a network of observation wells for measuring piezometric head in the deep aquifer.
- Preparation of a map of observation wells.
- Levelling of the reference points in each of these wells.
- Selection of network for water quality sampling.
- Establishing a unit for well monitoring. The size of this unit depends on the number of wells in the network and on distances between wells.

- Recording of water levels in hydrograph form after converting depth to water into elevation above sea level.
- Periodical sampling of pumping and flowing wells and chemical analysis of samples.
- Periodical measurement of discharge of pumping and flowing wells.

5.9 Final Report:

On terminating the Groundwater evaluation study a final report will be published. This report will be development oriented and will give in a practical way the full description of the work done and all the findings, facts, conclusions and directives in such a way that it may serve as a technical basis for all future groundwater development programmes in the district, the contents and table of contents will be edited in such a way as to conform with a standardised district groundwater resources evaluation reprot.

5.10 Data Base:

It is recommended to form a centralized Data base at the head office of GWRDB in Kathmandu. This is of utmost importance for the planning of the development of ground water resources. It is needed in order to make available in an orderly form, whenever required, all the information

and experience gained in the field. The information that will be collected is of two main types (a) information which does not change with time (depth of well, coordinates etc.) and (b) information which is time dependent (Water levels, discharge, chemical analysis). It will be necessary to develop the various forms appropriate for the recording of the collected information in such a way that in the future when a computerised information system is introduced it will facilitate the transfer of the information to that system. In the mean time it will have to be maintained in such a way as to enable an easy, uncomplicated and updated information. The following activities will be involved:

- Designing a form appropriate for recording constant well data (Name, owner, location, number, type, depth pipes, geologic log etc.).
- Record all available information on such forms.
- Designing of a form appropriate for recording time dependent well information (W.levels, discharge, chemical analysis).
- Record all available time dependent information on such forms.
- Preparation of files for each well.
- Introducing a centralised number system for the identification of each well.
- Preparation of key maps on scale 1:50,000 showing location of each well according to name and number and coordinates.

- Organize a control system with district or other field offices that will ensure the transfer or at least a copy of all data collected till now and that will be collected in the future.

TIME SCHEDULE

The time schedule for the completion of the groundwater evaluation and development project in the Terai depends on the professional personnel and drilling equipment that can be mobilized for this purpose and also on the duration of such an investigation in one average District.

It is estimated from past experience that the duration of such an investigation will be about 2 years, it is also expected that personnel for mustering 4 investigation teams will be available together with 6 drilling rigs. It is therefore proposed to adapt the following time schedule for the completion of project during Six years:

	Years					
	1	2	3	4	5	6
Investigations	11 districts (125 boreholes)	11 districts (125 boreholes)				
Development			11 districts (125 tubewells)	11 districts (125 tubewells)		

7. PERSONNEL, EQUIPMENT & OTHER REQUIREMENT

Personnel and other requirements will be given for a two year period. Requirements for the establishing of the monitoring network will be given for the first 2 years and for the ultimate stage. It is estimated that 8 field offices will be established.

7.1 Personnel requirements for monitoring network

	First 2 years	Ultimate stage
Hydrogeologists	4	8
Well observers	8	12
Assistant well observers	12	24
Technical clerks	8	8
Surveying teams	4	
Drivers	4	8

7.2 Equipment requirements

Four wheel drive pickups	4	8
Motorbikes	8	12
Bycycles	12	24
Water level indicators	25	40

7.3 Personnel requirement for groundwater evaluation projects

Project Coordinator (Senior Hydrogeologist)	1 x 24 m.
Hydrogeologists	8 x 24 m.
Geophysicist	2 x 6+6 m.
Geophysics operator (Assistant Geologist)	4 x 6+6 m.
Surveying teams	4 x 8+8 m.
Drivers	18 x 8+8
Drilling Crews	6 x 8+8
Compressor & pumptest crews	6
Workers	
Administrative staff, typist, draftsmen	
Tractor & heavy equipment opwrators	
Mechanics for Mechanical repairs	

7.4 Foreign Consultants

Team Leader (Senior hydrogeologist)	1 x 24
Senior Groundwater Hydrogeologists	2 x 12(3+3+3+3)
Drilling Engineer	2 x 8+8
Geophysicist	1 x 6+6
Senior Surface Water Hydrologist	1 x 4+4

7.5 Equipment Requirements

Four wheel drive pickups	6
,, jeeps	8
,, trucks	4
Wheel dozers	

Pumptest rigs (tractor mounted engines and gear heads	6
Spare pumps	2
Well logers	6
Drilling Rigs	6
Spare logers	2
Tractors	12
Water Tanker Trailers	6
Columns for each pumping set	40 m.
Bawl assembly (spares)	3

Surveying equipment, tripods etc.

Casing Pipes 2" blind 8,000 m(20x160+12x300+20x60)

2" perforated 2,800 m (20x40+12x100+20x40)

14" blind 4,500 m(100x45)

10" ,, 6,750 m(150x45)

8" ,, 6,500 m(100x65)

8" Screen 5,000 m (100x50)

6" blind 9,750 m (150x65)

6" Screen 7,500 m (150x50)

7.6 Expendable

- Combustibles & lubricants for vehicles drilling rigs, generator, Drilling mud, Camping equipments, bits and miscellaneous.
- Spare parts for cars, drilling rigs, pumps compressor generator.
- Office supplies.

7.7 Office Facilities

Office space in Kathmandu

Office facilities in Project area

Workshop and store rooms in Project area.

7.8 Miscellaneous

- Operation & maintenance of equipment:
  Maintenance and repair of vehicles, maintenance and repair of drilling rigs, maintenance and repair of scientific equipment, analysis of water samples.
- Local air travel.
- Office expenses.
- Reporting costs:
  Printing of periodic and final reports.

COST ESTIMATE

Based on current prices, the total cost of the project for the first 2 years period (Phase I) is estimated at US$ 2,830,000 including the equipments component (excluding drilling rigs vehicles & materials which is already available with GWRDB). A summary of the project cost for the first 2 years is given below. The details for the cost estimate and presented in Annex. 3. They are based on present salary levels, quotation from suppliers and on recently concluded contracts for similar works. The cost of the project for the second 2 years (Phase II) and the third two years (Phase III) is tentatively estimated to be about US$ 6,313,000 and US$ 4,995,000 respectively. Thus the total project cost for 6 years could be tentatively estimated to be about US$ 14,138,000.

Physical contingencies and price increases have no been provided at this stage in the cost estimate.

Summary of Project Cost - Phase I

(first 2 yrs. 125 exploration boreholes)

	K.Rs.	US$
1. Personnel requirements for monitoring network 1/	1,118,400	
2. Equipment requirement 2/		91,450
3. Personnel requirements for groundwater evaluation project 3/	1,696,300	
4. Foreign consultants 4/		1,000,000
5. Equipment requirement 5/		730,000
6. Expendibles 3/		812,500
7. Office facilities 3/	300,000	
8. Miscellaneous 3/	800,000	
	3,914,700	2,633,950
Equivalent US$	195,700	
Total US$		2,829,650
	Say US$	2,830,000

1/ Cost of this component for the second and subsequent 2 years will be about K.Rs. 1,296,000.

2/ Cost of this component for the second and subsequent 2 years will be about US$ 168,400.

3/ Cost of these components shall remain more or less the same for subsequent 2 years.

4/ Cost of this component in expected to be lower in the subsequent 2 years, as requirement of expatriate experts m/m will decrease.

5/ Cost estimate does not include cost of drilling rigs, and Casings. Cost of this component shall not be included in the subsequent 2 years except for casing which shall be about US$ 652,700 since the same equipments could be used in subsequent years.

Summary of Project Cost - Phase II

(2nd 2 yrs. 125 exploration bore-holes and Development of Phase I 125 wells for irrigation)

		N.Rs.	US$
1.	Personnel requirement for monitoring net work	1,296,000	
2.	Equipment requirement		168,400
3.	Personnel requirements for groundwater evaluation project	1,696,300	
4.	Foreign Consultants		600,000
5.	Equipment requirements		652,700
6.	Expendibles		812,500
7.	Office facilities	300,000	
8.	Miscellaneous	800,000	
9.	Development cost for irrigation		3,875,000
		4,092,300	6,108,600
	Equivalent US$	204,615	
	Total US$		6,313,215
	Say US$		6,313,000

Summary of Project Cost - Phase III

(3rd 3 yrs. Development of Phase II - 125 tubewells for irrigation)

	N.Rs.	US$
1. Personnel requirements for mohitoring net work	1,296,000	
2. Foreign Consultants		100,000
3. Office facilities	300,000	
4. Miscallaneous	800,000	
5. Development cost for irrigation		3,875,000
	2,396,000	4,875,000
Equivalent US$	119,800	
Total US$		4,994,800
	Say US$	4,995,000

Summary of Basic Data by Districts (From D.Tillsons report May 19

1. Kanchanpur District (Mahakali Zone)

(a) Investigation by USAID/USGS. 15 investigation wells including aquifer pumping and flowing tests, quality analysis mostly 122/244 meters deep and some to 457 m. located on grid pattern with district wide distribution.

(b) Investigation by GWRDB 15 production wells 91-152 m. deep with well and aquifer pumping test data and electric logs, located in flowing artesian zone confined and unconfined static water levels.

2. Kailali District (Seti Zone)

(a) Investigation by USAID USGS: 30 investigation wells including pumping and flowing test, mostly 122-152 meters deep and some to 457 m. located district wide on systemat grid basis. Water quality analysis.

(b) Investigation by GWRDB: 06 production wells with well and aquifer pumping test and electric logs, wells generally 91-152 m. deep, located in flowing artesian zone. Confine and unconfined static water levels.

(c) Dhangari Project: Investigation by Water and Power Development Consultancy Services. Feasibility study of Dhangari Groundwater Development Project, Cost Estimate, Feasibility, Groundwater recharge, Potential, Cropping Patterns water requirement, Interpretation of hydrogeological data, Geology development and implementation plan, Project justification groundwater regime, Well specifications capacities.

3. Bardia District (Bheri Zone):

Investigation by USAID/USGS: 19 investigation wells commonly 122-152 meters deep and some to 366 m. located on a district wide grid pattern, aquifer/pumping and flowing test, water quality analysis, confined and unconfined static water levels.

4. Banke District:

Investigation by USAID/USGS: 26 investigation wells including aquifer pumping tests commonly 122-152 meters deep and several to 457 m. Water quality analysis, wells located on a district wide grid pattern. confined and unconfined static water levels.

5. Dang Deokhuri District (Rapti Zone):

No data available on subsurface conditions of Dang Valley or Rapti River Valley.

6. Kapilvastu District (Lumbini Zone):

Investigation by USAID/USGS: 31 investigation wells 61-213 meters deep with maximum of 300 m. deep, wells placed on grid pattern with district wide distribution. Aquifer pumping and flowing tests, water quality analysis, confined static water levels.

7. Rupendehi District:

(a) Investigation by USAID/USGS; 48 investigation wells located on a district wide grid pattern, 122-213 m deep with several to 300-457 m. deep, aquifer pumping and flowing tests, water quality analysis.

(b) Bhairahwa-Lumbini Ground Water Project: Investigation by TAHAL Consulting Engineers Ltd. :- Groundwater recharge, groundwater potential, water use cropping pattern, water requirements, hydrogeological interpretation of data, development and implementation plan, cost estimates, project justification, well requirements, groundwater regime, 50 wells lithologic logs, electric logs, well pumping tests, aquifer tests, wells about 100-150 m. deep, concentrated in Project area, confined and unconfined static water levels over period of 3-5 years, h drographs.

8. Rawal Parasi District:

Investigation by USAID/USGS: 16 wells commonly 91-152 meters deep with two to 305 m. well logs, aquifer pumping and flowing tests, water quality analysis, wells placed on grid pattern district wide, confined aquifer static water levels.

9. Chitwan District (Narayani Zone):

No data available for Chitwan Valley.

10. Parsa District:

Wells are adjacent to Bara District and are described in that district.

11. Bara District:

(a) Investigation by Irrigation Department: More than 10 wells (total unknown) with well logs, construction, pumping test results depth range 100-130 meters.

(b) Narayani Zone Irrigation Development Project : Tubewell irrigation section: - Fourteen production wells 136-171 meter deep, well log, well performance pumping tests, well construction, project cost, production records, confined and unconfined static water levels.

(c) Birgang, Investigation by Nippon Koei Engineers: Narayani Groundwater Project, groundwater recharge, groundwater potential, water use, cropping pattern, water requirement hydrogeological interpretation of data, development and

implementation plan, well requirements, aquifer systems, groundwater flow, hydrographs, project justification, model for hydrogeological changes, withdrawal cost estimates, geology, well dimensions.

12. Rautahat District:

No data available.

13. Sarlahi District (Janakpur Zone):

(a) Investigation by department of irrigation: 11 wells 73-107 meters deep concentrated in south central portion of district, well logs, well construction, aquifer pumping test, confined static water level from 11 deep wells in Malangwa area. Unconfined water levels district wide except south west and north west portion.

(b) Investigation by Nippon Koei Engineers: Feasibility study of Sunkosi Terai Project (also for Mahottari district) well logs, well construction, aquifer test result, well capacities and dimensions, groundwater potential, groundwater regime geology, aquifer distribution, resistivity survey. Preliminary feasibility study, hydrogeology of terai plan, redius of influence, well interference, chemical analysis of water samples, pheatic water levels for Janakpur area and Malangwa area.

14. Mahottari District:

(a) Investigation by Janakpur Agricultural Development Project: 4 test production wells, 112-175 meters deep. Well logs, pumping test data confined and unconfined static water levels throughout the district.

(b) Investigation by Nippon Koei Engineers: Geoelectric soundings, water table contours, hydrographs, shallow aquifer permeability, test well logs, aquifer pumping test result, well lithologic logs, electric logs, piezometric heads.

15. Dhanusha District

Investigation by Janakpur Agricultural Development Project: 5 available deep test production well logs, well construction, pumping test, 9 intensive irrigation production wells, 130-200 m. deep well logs, electric logs, well construction, well performance pumping tests, flow records. 3 Haraincta farm production wells, well construction and well logs, comprehensive coverage of District Static water levels for confined and unconfined aquifers.

16. Siraha District (Sagarmatha Zone):

(a) Investigation by Irrigation Department: 7 wells mostly 114-138 meters deep, well logs, aquifer pumping test results, well construction, concentrated in south west corner of district.

(b) Investigation by Ground water Resources Development Board: 5 test production wells mostly 70-97 meters deep. Well logs, electric logs, well construction, aquifer pumping test, located in north half of District. Confined static water levels available in the eastern part of district unconfined static water levels.

17. Saptari District

Investigation by GWRDB: 10 test production wells depth 91-125 m. District wide distribution grid location, well logs, well construction, electric logs, aquifer pumping test.

18. Sunsari District (Koni Zone):

Investigation by GWRDB: 10 production wells 91-125 meters deep, District wide distribution grid location, well logs, well construction, electric logs, aquifer pumping test.

19. Morang District:

Investigation by GWRDB: 3 test production wells 91-131 m. deep, well logs, well construction, electric logs, aquifer pumping test data.

20. Jhapa District (Mechi Zone):

No available subsurface data unconfined Static water levels available for western half of district.

Implementation Schedule for each District

Months / Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Compilation & study of existing information																								
Geological Study																								
Geoelectrical investigation																								
Drilling program																								
Hydrogeological study																								
Hydrometeorological study																								
Groundwater development planning																								
Monitoring network																								
Final Report																								

Details of Cost Estimates

1. Personnel requirements for monitoring net work (N.Rs.)

			Firsty 2 years		Ultimate stage
Hydrogeologists	1600/m	4x24	153,600	8	307,200
Well observers	1000/m	8x24	192,000	12	288,000
Assistant well observers	800/m	12x24	230,400	24	460,800
Technical clerks	700/m	8x24	134,400	8	134,400
Surveying teams	3700/m	4x24	355,200		
Drivers	550/m	4x24	52,800	8	105,600
			1,118,400		1,296,000

2. Equipment requirements (US$)

Four wheel drive pickups	15000	4	60,000	8	120,000
Motorbikes	3000	8	24,000	12	36,000
Bicycles	100	12	1,200	24	2,400
Water level indicators	250	25	6,250	40	10,000
			91,450		168,400

3. Personnel requirements for groundwater evaluation project (N.Rs.)

Projett coordinator (Senior hydrogeologist)	1900/m	1x24 m	45,600
Hydrogeologists	1600/m	8x24 m	307,200
Geophysicist	1600/m	2x6+6 m	38,400
Geophysics operator (assistant geologist)	1000/m	4x6+6 m	48,000
Surveying teams	3700/m	8x8+8 m	473,600

Drivers	700/m	18x8+8 m	201,600
Drilling Crews	500/day	6x8+8	120,000
Compressor & pump test crew	250/day	6	60,000
Workers, Administrative Staff, Typist, Draftsmen, Tractor & heavy equipment operators, Mechanics for Mechanical repairs.		L.S	400,000
			1,696,300

4. Foreign Consultants (US$)

Team Leader (Senior hydrogeologist)	1 x 24	
Senior groundwater hydrologists	2 x 12 (3+3+3+3)	
Drilling Engineer	2 x 8+8	
Geophysicist	1 x 6+6	
Senior surface water hydrologist	1 x 4+4	
Total m/m	100 x 10,000	1,000,000

5. Equipment requirements (US$)

Four wheel drive pickups	6	15,000x2	30,000	(4 existing
,, jeep	8	14,000	112,000	
,, trucks	4	25,000	100,000	
Wheel dozers	2	100,000	200,000	
Pumptest rigs (tractor mounted engines & gear heads.	6	30,000x4	120,000	(2existing.
Spare pumps	2			(existing)
Well logers	6			(,,)
Spare logers	2	5,000	10,000	

Drilling rigs	6 - existing		
Tractors (50-60 HP)	12	15,000x6	90,000(6 existing)
Water tanker trailers	6	4,000x3	12,000(3 existing)
Columns for each pumping rig (included in cost of pumps)	40 m		
Bawl assembly(spares) +spare parts	3	4,000	12,000
Surveying equipment tripods etc.			44,000
			730,000
Casing Pipes 2" blind 8,000m (20x160+12x300+20x60) - 7			56,000
2" perforated 2800m (20x40+12x100+20x40) - 9			25,200
14" blind 4,500 m - 55x2,500			137,500(200m existing)
10" ,, 6,750 m - 42x2,750			115,500(400m ,,)
8" , 6,500 m - 33x2,500			82,500(400m ,,)
8" screen 5,000m - 40 x 3500			140,000(1500m ,,)
6" blind 9,750 - 25			(existing)
6" screen 7,500 - 32 x 3000			96,000(4500m ,,)
			652,700
Expendable (US$)			
Fuel, lubricants, spareparts, drilling mud, cement, and other expendable materials. for 125 tubewells @6,500/well			812,500
		US$	812,500

7. Office Facilities (N.Rs.)

Office space in Kathmandu

Office facilities in Project area

Workshop & store rooms in Project area L.S. N.Rs. 300,000

8. Miscellaneous

Operation & maintenance of equipment:

Maintenance & repair of vehicles, maintenance & repair of drilling rigs, maintenance and repair of scientific equipment, analysis of water samples.

Local air travel

Office expenses

Reporting Costs:

Printing of periodic and final reports L.S.N.Rs. 800,000

9. Cost of Development for Irrigation (N.Rs.)

(A) Pumphous construction	N.Rs.	60,000/well
(B) Irrigation net work	N.Rs.	300,000/well
(C) Procurement & Installation of Pumps & Diesel Engines	N.Rs.	260,000/well
	Total Rs.	620,000/well

Equivalent US$ 31,000/Tube wells

or US$ 3,875,000(125 wells)

or US$ 7,750,000(250 wells)

Detail estimate of expendable/Borehole (N.Rs.)

A.	Fuel for approach road preparation, Drilling rigs, auxillary equipments, Compressor, Pump test engine, vehicles etc.	5000 l x Rs. 7.5 =	Rs 37,500/-
B.	Repair & maintenance including spare parts for machinaries	L.S.	Rs 22,000/-
C.	Drilling mud, Chemicals & Cement	L.S.	Rs 20,000/-
D.	Drilling bits & tools		Rs 24,000/-
E.	Fittings & materials for fabrication	L.S.	Rs 12,000/-
F.	Camping equipments		Rs 8,000/-
G.	Miscallaneous & unforseen	L.S.	Rs 6,500/-
		Total	Rs130,000/well

Equivalent US$ 6500/tubewells.

or US$ 812,500 (125 tubewells)

or US$ 1,625,500 (250 tubewells)

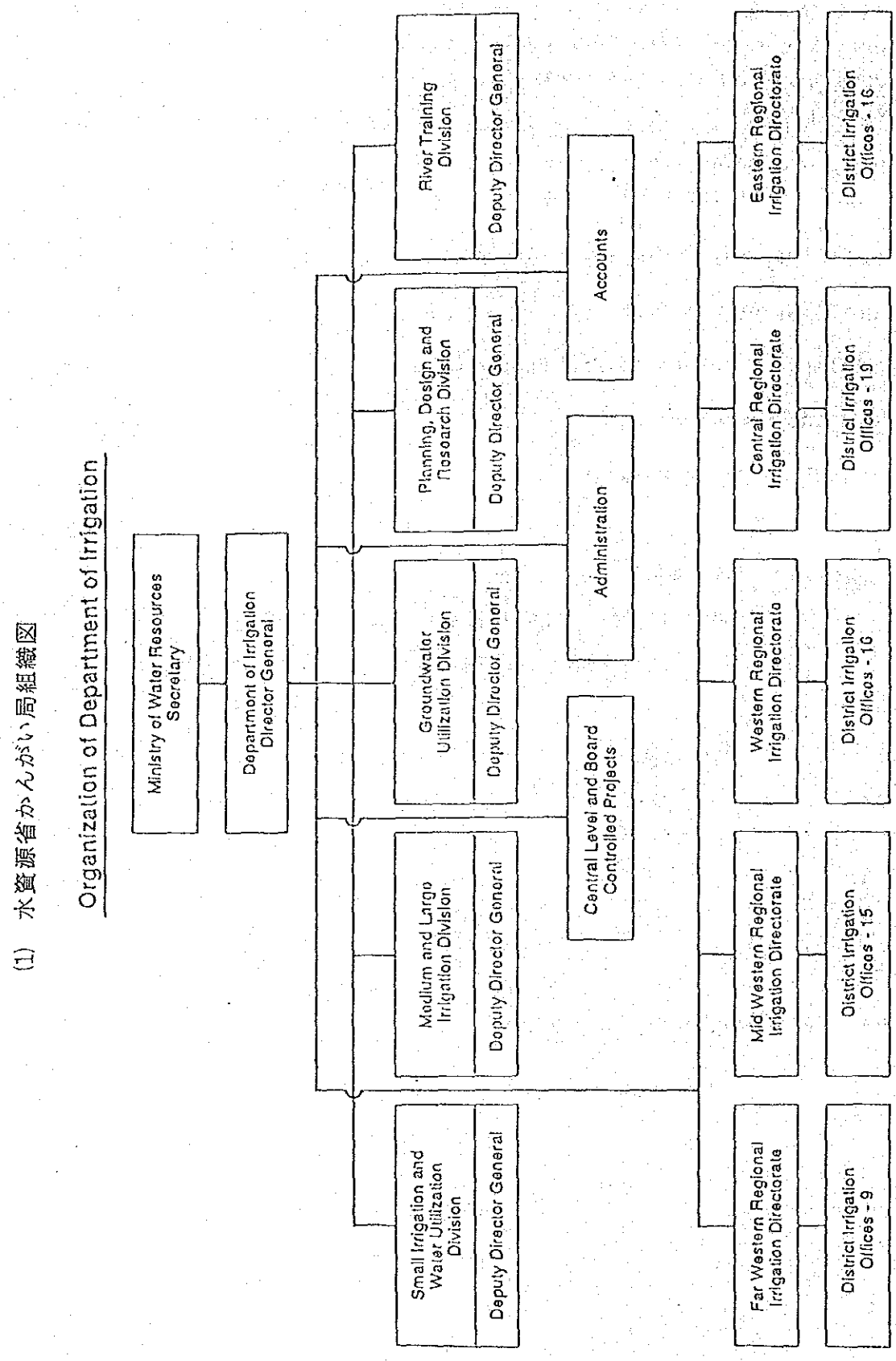
DETAIL COST OF SURVEY TEAM

Employee	Nos.	Rs./month	Total Rs/month
Surveyor	1	1000	1000
Helpers	2	600	1200
Workers	3	500	1500
		Total	3700

Rounded cost/month Rupees 3,700

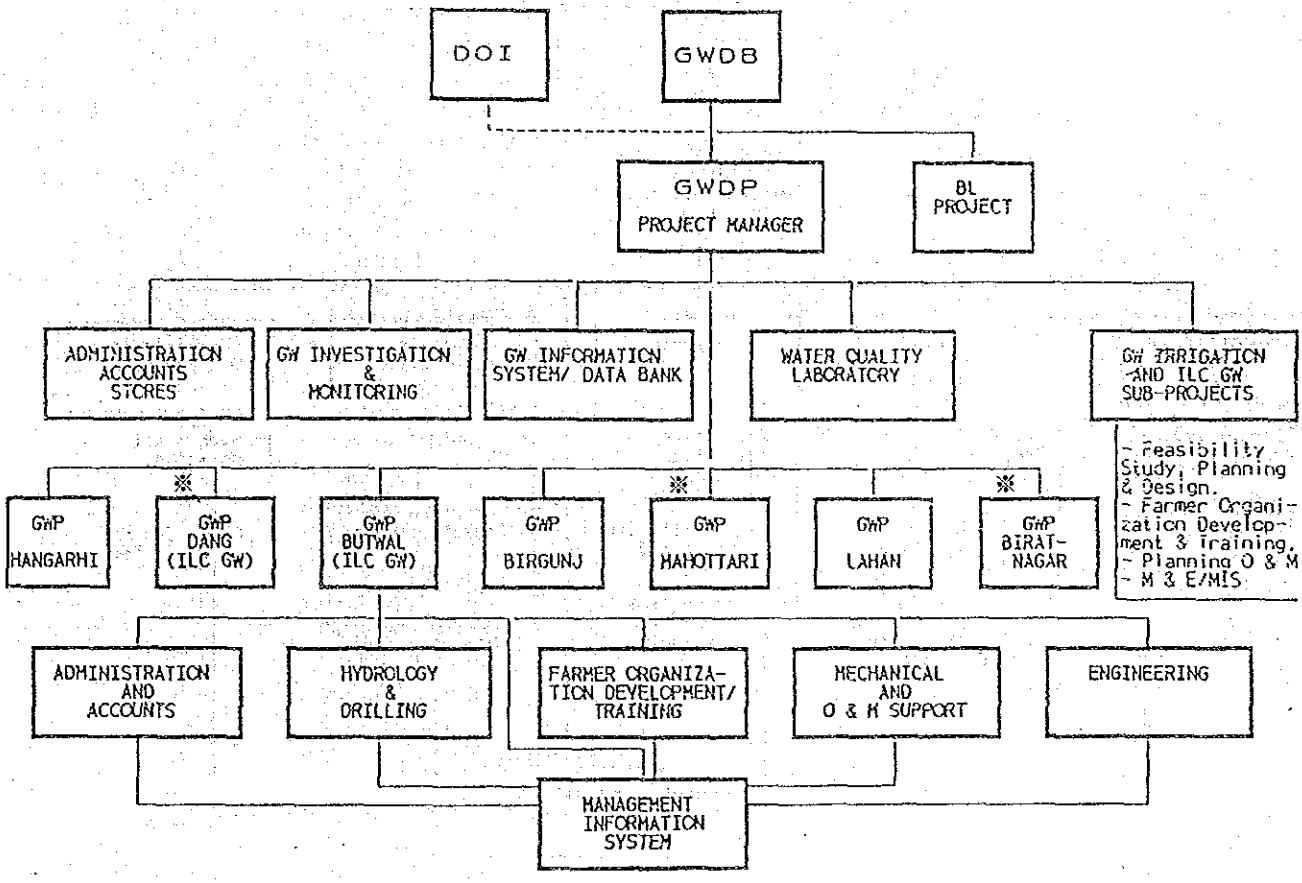
付属資料 4.　関係機関組織機構資料

(1)　水資源省かんがい局組織図



(2) 地下水開発プロジェクト組織図

ORGANIZATION AND COORDINATION CHART OF GWDP



（略注）

DOI ：Department of Irrigation

GWDB：Ground Water Resources Development Board

（議長；水資源省次官，構成員；かんがい局長，同局次長，国家電力庁代表，大蔵省代表，国家計画委員会代表，農業開発銀行代表）

GWDP：Ground Water Resources Development Project

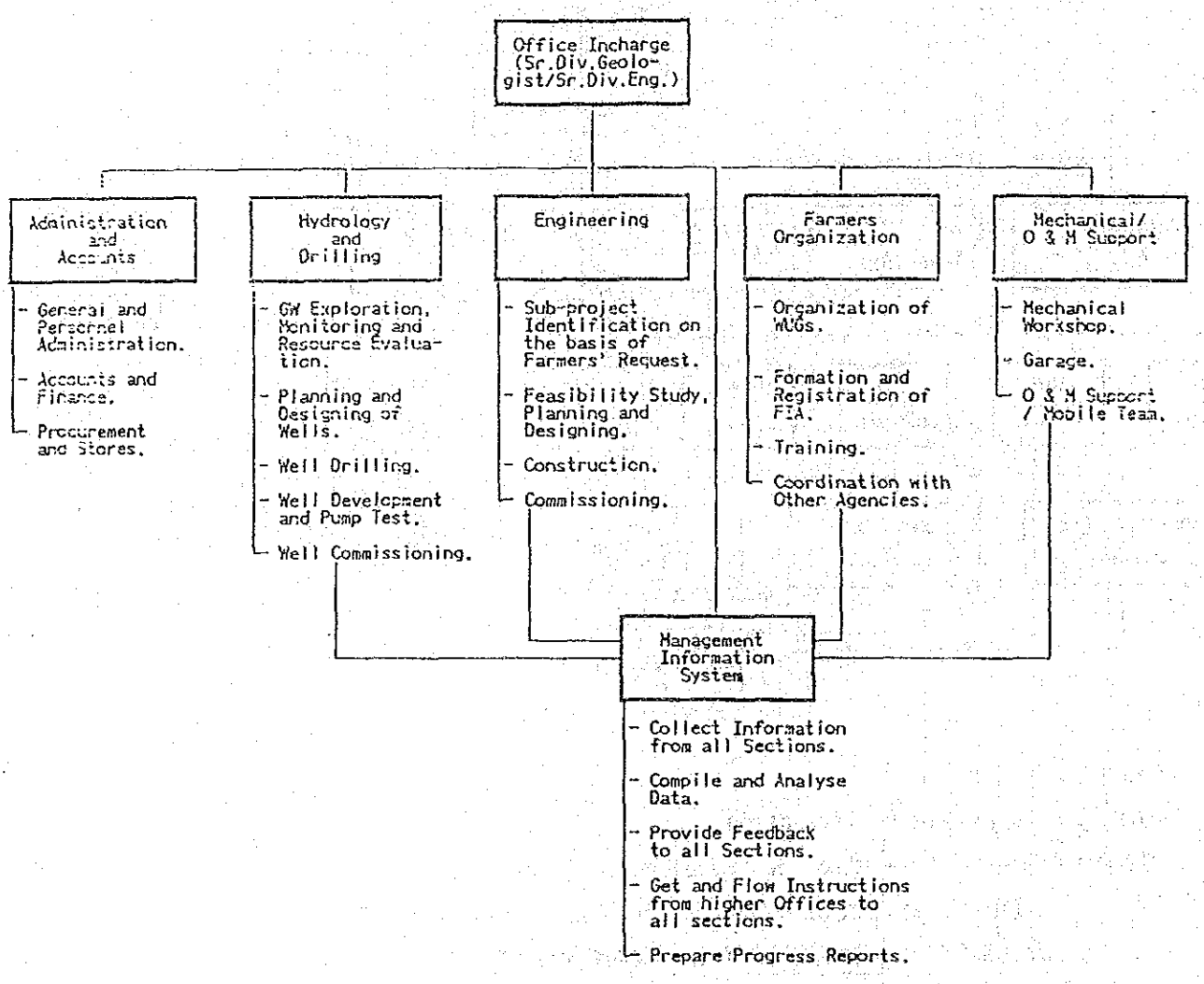
BL Project：Bhairawa Lumbini Groundwater Irrigation Project

ILC ：Irrigation "Line of Credit"

※：本件調査に関わる地方事務所

(3) 地下水開発プロジェクト地方事務所組織図（典型例）

Typical Organization Chart of GWDP Field Office



(4) GWDP事業本部の職員構成

Present Staff/GWDL Main Office Kathmamndu

	Post	Nos.
1.	Project Incharge (Superintendent Geologist)	1
2.	Senior Divisional Geologist (Hydrology)	2
3.	Senior Divisional Engineer (Irrigation)	1
4.	Senior Divisional Chemist (Water Quality)	1
5.	Divisional Geologist	1
6.	Divisional Chemist	1
7.	Geohydrologist	4
8.	Hydrologist	1
9.	Chemist	3
10.	Assistant Engineer	2
11.	Account Officer	1
12.	Procurement Officer	1
13.	Administrative Officer	1
14.	Technical Assistant	3
15.	Draftman	1
16.	Driller	1
17.	Senior Mechanics	1
18.	Computer Operator	1
19.	Civil Overseer	3
20.	Administrative Assistant I	2
21.	Procurement Assistant I	1
22.	Store Keeper	1
23.	Accountant	2
24.	Typist	5
25.	Assistant Computer Operator	1
26.	Wireless Operator	1
27.	Store Assistant II	1
28.	Jeep Driver	5
29.	Laboratory Boy	3
30.	Peon, Watchman	7
		59

(5) GWDPマホタリ地方事務所の職員構成

Present Staff / GWDP, Field Office Mahottari

	Post	Nos.
1.	Office Incharge (Senior Divisional Geologist)	1
2.	Geohydrologist	1
3.	Assistant Engineer	1
4.	Senior Driller	1
5.	Assistant Geologist	1
6.	Driller	1
7.	Well Observer	1
8.	Senior Mechanics	2
9.	Civil Overseer	2
10.	Store Keeper	1
11.	Accountant	1
12.	Administrative Assistant I	1
13.	Farmer Association Organizer	1
14.	Assistant Driller	2
15.	Typist	1
16.	Pumping Test Assistant	2
17.	Junior Welder	1
18.	Store Assistant	1
19.	Heavy Driver	according to nos. of vehicles
20.	Jeep Driver	do
21.	Pumping Test Helper	1
22.	Driller Helper	4
23.	Peon, Watchman	6
		33

(6) GWDPダン・バンケ地方事務所の職員構成

Present Staff / GWDP, Field Office Dang/Banke

	Post	Nos.
1.	Office Incharge (Sr. Div. Geologist)	1
2.	Geohydrologist	2
3.	Assistant Engineer	1
4.	Assistant Geologist	1
5.	Assistant Ground Water Hydrologist	1
6.	Driller	3
7.	Well Observer	1
8.	Senior Mechanics	1
9.	Civil Overseer	1
10.	Accountant	2
11.	Administrative Assistant I	1
12.	Procurement Assistant I	1
13.	Farmer Association Organizer	4
14.	Assistant Driller	2
15.	Typist	1
16.	Pumping Test Assistant	1
17.	Junior Welder	1
18.	Administrative Assistant II	1
19.	Heavy Driver	2
20.	Jeep Driver	2
21.	Driller Helper	4
22.	Peon Watchman	5
		36

(7) GWDP プトワル地方事務所の職員構成

Present Staff/GWDP, Field Office Butwal

	Post	Nos.
1.	Office Incharge (Senior Engineer)	1
2.	Geohydrologist	2
3.	Assistant Engineer	1
4.	Mechanical Engineer	1
5.	Senior Driller	1
6.	Store Officer	1
7.	Sr. Accountant	1
8.	Assistant Geologist	1
9.	Driller	2
10.	Senior Welder	1
11.	Senior Mechanics	2
12.	Civil Overseer	3
13.	Store Keeper	1
14.	Accountant	1
15.	Store Assistant I	1
16.	Farmer Association Organizer	4
17.	Assistant Driller	2
18.	Typist	1
19.	Pumping Test Assistant	1
20.	Heavy Driver	as required
21.	Jeep Driver	do
22.	Pumping Test Helper	1
23.	Driller Helper	4
24.	Peon	3
25.	Watchman	4
		40

付属資料５．主要な大規模農業水資源開発事業概要

(1) イースタン　テライ　かんがい事業

この事業は、ダンス／マリア、バクラ河川表流水と、90ヵ所の深井戸を利用する連結利用型の事業である。農民管理かんがい計画による表流水により、7,000 haが用水供給を受けている。事業は、モンスーン期の水の確保性の改良と冬季の作付を可能にするためのものである。

２河川の頭首工の建設案は、簡単な蛇籠を使った堰で、主にコストのかかるものは深井戸とその関連施設である。計画必要水量の40％は表流水で計画されている。調整は90の深井戸によることとし、80ℓ／ｓの水量を見込んでいる。水不足問題が生じないように、井戸の仕組み上重要であるバックアップ容量を見込んでいる。

(2) バグマティ　かんがい事業

バグマティ堰とかんがいシステムの建設は、ＨＭＧＮ資金により1980年に始まった。事業の完成は1992年の予定である。事業には、長さ 400mの取水堰、30の洪水吐、６の土砂吐、２の魚道が含まれている。堰は、イーストウェストハイウェイから上流にあり、サルハリ、ラウタハット郡のそれぞれの川の左右両岸の水路システムを支配している。支配面積37,000ha（左岸14,000ha、右岸23,000ha）は、ステージＩ事業でかんがいされたものである。1988年のコストの概算によると、1988年半ばまでに60,240万ルピーが建設費に使われている。さらに1988年から1991年までに60,680万ルピーが使われることになっている。この経費の大部分は、堰のゲートに必要であり、この組立は中国が請け負っている。

水収支によると、37,000haがモンスーンシーズンに確実に供給され、地域の約25％（12,000ha）で冬場のかんがい作物の作付ができるとされている。支配面積はモンスーン時期に47,800haに広がるが、冬季の作付けのもとでは、供給水の制限のために一定に保たれることとなる。

(3) イースト　ラプティ　かんがい事業

イーストラプティかんがい事業は、チトワン渓谷のナラヤニ川の支流であるイーストラプティ川で行われる。事業は、イーストラプティ川右岸の支配面積 9,500haに対して、年間の水供給を確実にするものである。かんがい工事は、10haのブロックで構成された第３次システムにより、支配面積拡大レベルで開発される。事業の実施は、1992年に初めて水がくる予定の地域で、ＤＯＩに委任されている。実行可能な調査は、1986年に終了したが、アジア開発銀行の資金によるものである。

事業は、事業地域に水を分水するために、ロタール川との合流地点の直下流に、高さ 2.6mの堰を建設する河川水開発事業である。堰は、30mのスルースゲートが付いており、長さは 370m

である。最上流部の水路は、容量14.3㎥／ｓ、長さ1.4㎞である。幹線水路は延長24㎞である。

事業は、18,400haの純支配面積をもつが、現在12,500haが農地であり、残りが森林、道路、河川などである。農地のうち 1,390haがＤＯＩのロタール、ピツワかんがい計画によりかんがいされている。加えて、天水による農民管理かんがい計画で 2,810haがかんがいされている。

(4) マルチワル 揚水かんがい事業

マルチワル揚水かんがい事業は、チナウ、ドナ川からルパンディヒ郡のチナウ川左岸の地域に水を供給するものである。配水システムの建設は1985年に始まったが、ポンプ場の建設のための追加資金の要請と認可を得るのが遅れているため、1988年に停止された。1989年の初期に、ＵＮＣＤＦの支援による派遣団が追加開発工事の必要性とＵＮＣＤＦからの一層の資金について評価するため、事業地区を訪れている。派遣団の調査に基づき、建設事業は1994年に完成させること、追加資金は約 650万ドルとされた。

事業は、当初支配面積 4,400haとされていたが、土地と水資源の有効な評価に基づいて、5,600haに拡大された。ポンプ場は、揚程が少し違う（4.4mと5.5m）地域に揚水する。能力は併せると 6.5㎥／ｓである。

(5) シクタ かんがい事業

シクタかんがい事業は、ウェストラプチ川から調整無しの取水によるバンケ郡の36,070haのかんがい開発のための事業である。工事は、アガイヤ村付近のウェストラプチ川の取水堰、左岸の小地域（ 1,800ha）を賄う短い水路システムと、残りの事業地域に水を運ぶ36㎞の右岸支線水路を含んでいる。長い支線水路は、可能性調査において、ウェストラプチの低平地は有効でないために、自然あるいは揚水による配水が必要であると結論付けられたためである。

(6) ババイ かんがい事業

ババイかんがい事業は、河川の自然流水を使って行う、バルディヤ郡のババイ川左岸の13,500haのかんがい開発のための事業である。事業には、 270mの長さの取水堰、幹支線水路、用排水システムが含まれている。堰は、イーストウェストハイウェイに必要な橋と一緒になっている。ハイウェイの建設は進行中であり、工事は、ババイ事業でも始まったところである。1990年代遅くに完成する予定である。

(7) マハカリ かんがい事業 ステージ II

マハカリかんがい事業のステージIIは、カンチャンプルのテライ平野の極西部の現在かんがいの行われていない地域のうち 6,800haのかんがいを可能にする支援を行うものである。マハカリ事業としては、11,800haの支配面積になる。事業の建設は、ＩＤＡのもとで資金が供給されてい

る。ステージⅠもＩＤＡの支援を受けた事業であり、1988年12月に終わっている。

マハカリ事業地域は、水の利用可能量の変動余地がないという珍しいところである。これは、事業の水供給が、1920年のサルダ事業の同意の期限に基づいて、インドによって行われているからである。雨期（５／15～10／15）は13㎥／ｓの流量、乾期は 4.3㎥／ｓが供給される。同意によると、余剰水が使えるときは増量の申し出ができるが、ネパールに供給する流量は一般に総量が制限される。事業は、水の有効性に付いて乾期に問題があるため、ステージⅡ地域の付近に井戸の配置を増やすことを認めている。これは、水不足問題を軽減させるものである。

(8) バイラワ　ルンビニ　Ⅲ　深井戸事業

バイラワルンビニⅢ事業は、 8,600ha以上の面積にかんがいするための十分な深井戸の敷設により、ルパンディヒ郡のバイラワルンビニ事業（全開発時11,900ha）の委託と既存事業を拡大する事業である。

新たな開発は、３地域で行われる。

東部地域	3,000ha	49tubewells
西部地域	1,400〃	12　〃
中央地域	4,200〃	35　〃
合　計	8,600ha	96tubewells

それぞれの地域内の事業は、井戸の建設、配水網、配電システム、排水施設、農道の連接である。事業施設の管理も構築され、維持管理と農業拡大プログラムが事業のもとで行われている。ステージⅡで試験された環状埋設管排水システムは、ステージⅢ全域で提案されている。埋設管システムは、水の損失を減少させ、起伏ある地形状態の区域の水調整の改善、かんがい施設のための潰れ地の減少という有利性をもっている。

(9) カンカイ　多目的事業

カンカイダムは、ジャバとイラム郡の東部で始まる中規模河川であるカンカイ川に計画されている。高さ85mのフィルダムで行われる流量調整は、67,000ha以上の支配面積に対して、年間を通したかんがい水の供給を行うものである。隣接する発電所の発電設備は、６万kwの設備能力で、年間約２億kwの安定したエネルギーを発生させる。ダムサイトへの接近は良好であり、イーストウェストハイウェイから上流４kmにある。

カンカイダムで行われる供給水の調節によって利益を受ける地域は、ＤＯＩの現在のカンカイ事業（ 8,000ha）と農民管理かんがい計画の24,500ha以上を含んでいる。カンカイ事業は、農民管理かんがい計画がモンスーン期にだけ可能である河川水による事業であるため、年間かんがい可能地域、拡大開発計画に分類される。事業地域の残りの地域は、現在天水による耕作地である。

事業によって影響を受ける重要な森林地域はない。

以前の調査で最大の支配面積は67,000haと評価されていたが、政府の現在の考えは、後日のかんがい開発の完了後に行うことができるものとして、約半分の面積（38,000ha）で開発事業を始めることである。下流の水需要のために完成が限りなく延期される前に、開発の小規模版が、単独事業として経済的に実行可能になるように要望されている。

水収支計算では、67,000haの支配面積では、もし貯水操作がかんがいの需要面から決定されるならば、年間を通したかんがい供給がなされるだけである、と結論付けている。もし電力によって決定されるならば、可能面積は、37,000haに減少する。

(10) カマラ　多目的事業

カマラ多目的事業は、1970年代のはじめに行われた東部テライのかんがい可能性調査で初めて評価された。貯水は、チサパニ村から約20km上流のカマラ川に建設するダムで行われる。堰はチサパニに建設され、左岸の51,000ha（シラハ郡）と右岸の45,000ha（ダヌーシャ郡）、合わせて96,000haの支配面積に配水する。ダムの発電所は3万kwの設備能力があり、年間 7,500万kwの安定したエネルギーを発生させると評価されている。事業は、スンコシ分水事業案に取り入れられている。単独事業として、あるいはスンコシーカムラ開発の第一段階として見なすことができる。

初期の調査に一致している支配面積の96,000haは、現在の25,000haのカムラ事業を含み、2の小規模なＤＯＩ計画と農民管理かんがい計画約21,000haも含んでいる。これらの全ての計画は、モンスーン期だけであり、事業では、年間を通して水を供給するようになっている。

(11) スンコシーカマラ　分水事業

スンコシーカマラ分水事業は、1972年のテライ平野のかんがい可能性調査の中で初めて正式に提案され、1984年のＪＩＣＡによるコシ流域マスタープラン調査でより詳細に調査された。カマラ流域の水資源は、スンコシ川からの72㎥／ｓ分水によって増やされており、カマラに近いスンコシの低いダムと16.6kmの長いトンネルによってつながっている。また、61,400kwの発電所がある。分水は、カマラダムサイトから上流のカマラ分水点に入る。カマラダムと連立する32,000kwの発電所の建設によって自流と分水された流量は、チサパニ頭首工地点から175,100 haに供給するために再調整される。カマラダム発電所は32,000kwの設備能力をもつ。二つの頭首工開発を連続することは可能である。ＪＩＣＡレポートは、カマラダムの建設とかんがい工事の後で、分水トンネルの建設と55,000haの支配面積のためのかんがい工事を提案している。いずれにしても、分水堰の完成とかんがい区域の拡大の後に、はじめてカマラダムを建設することができるのである。

ＪＩＣＡレポートで提案されている支配面積は 175,100haと非常に大きく、その内訳は、左岸67,200ha（シラハ、サプタリ郡）、右岸 107,900ha（ダヌーシャ、マホタリ、シラハ郡）となっ

ている。現在水不足であるいくつかのＤＯＩ計画（ＳＩＲＤＰの構成事業のカマラ、ハルディナタ）は、追加する供給水で恩恵を受ける。モンスーンタイプのかんがいを受けている大半の現在の農民管理かんがいシステム約50,000haも利益を受けるであろう。当初案の概要では、右岸の幹線水路がバグマティ多目的事業の可能性によって恩恵を受ける地域に広がっていた。支配区域の重複は、調査において、約42,000haとみられていた。左岸幹線水路は非常に長く（70km以上）、いくつかの重要河川や渓谷を横切る。また、右岸幹線水路は短いが、いくつかの主要な渓流横断がある。

水収支計算は、ＪＩＣＡレポートにあるように分水流量は72㎥／ｓに制限されており、年間かんがいの作付が拡大できる最大の支配面積は、約 138,000haであると結論付けている。しかしながら、分水地点におけるスンコシ低水流量の信頼性が、提案されている分水流量より実質的に高いことから、分水トンネルの拡大によって追加流量を供給する余地がある。（月間90％最小流量は126㎥／ｓとみられる。）

⑿ バグマティ多目的事業

バグマティ多目的事業は、ほとんど完成しているバグマティ堰の上流に、 117mの高さのロックフィルダムを建設するものである。発電所は14万kwの設備能力をもち、年間５億４線万kwh の農事用電力を発生することとなっている。事業は、ドイツの技術協力により、1980年に実行可能なレベルで調査された。事業コストの見積りは、ＮＥＡの最小コスト人口拡大を準備するための事業計画の一部として、1986年に改訂され、評価されている。当初の調査にしたがってダムから放流される調節された流れは、12万haの年間かんがいのために供給される。計画区域は、現在モンスーン時期のかんがいのために建設中である河川水によるバグマティかんがい事業を包含している。多目的事業は、現在の天水地域（約68,000ha）に新しいかんがい施設の建設を行い、今の計画を改善するものである。

スンコシーカマラ分水事業に関して述べられているように、当初の案のバグマティ供給区域はスンコシーカマラ分水事業案の区域と重複している。しかし、二つの事業の境界を変えたため、バグマティ多目的事業の支配面積は 107,000haに増え、東側の事業境界はサウラリーマホタリ郡境界におかれている。

水収支計算は、もし貯水が最初の優先順位としてかんがい需要に応じて操作されるならば、貯水ダムが年間を通して水を供給する12万haの支配面積の需要に応じることができると結論付けている。もし、電力需要が操作状況を支配するならば、実行できる支配面積は76,200haに減る。しかし、妥協した操作パターンでも、支配面積は10万ha以上に増加することとなる。

⒀ カルナリ　多目的事業

カルナリ多目的事業は、ヒマラヤンパワーコンサルタンツ（ＨＰＣ）によって1986年以来調査

されているところである。事業上の重要な中心は、カルナリ川がテライ平野に出るところから上流5㎞地点のチサパニの堤高270mのロックフィルダムである。ダムは、160億㎥の貯水量があり、最大 1,080万kw以上の設備能力が見込まれている。ダムで発生する水力発電エネルギーはネパールだけで十分使いきれないため、インド政府といっしょに北インドの消費者の必要に応じての売却について議論中である。

チサパニダムは、需要のピークにエネルギーを発生させるよう一年中ほとんどの時間に使われ、また、むだに越流しないように発電所から連続して放流される。変動する放流パターンと緩やかな流量変化（特に乾期の間）を要求する下流の利水者のために、高さ20m、長さ5㎞の下流調整ダムの建設（コスト約 500万ドル）を必要とする。このダムからの放流、比較的一定になる。また、84,000kwの設備能力をもつ発電所は、調整ダムからの越流の一部を利用するものである。

ネパールの主要なかんがい開発が、カルナリ開発の全体を完成させるのに必要な一部分として提案されている。総支配面積83,320haの東岸（バルディア、バンケ郡）、西岸の90,630ha（カイラリ郡）、グルワ島地域の農民事業改修15,000ha、あわせて 190,950haである。新かんがい開発は、ＤＯＩのいくつかの既存の事業（ 5,843ha）、農民管理かんがい事業（約55,000ha）と合わせて実施される。既存の事業のほとんどは乾期に水が不足する。両岸の幹線水路の路線設定は、ＨＰＣによって行われた。それは、要請に基づく地域と小さな低揚程揚水計画によって供給されるいくつかの地域を最大限活用するものである。東岸では、水路は王立バルディヤ野生動物指定地区への重大な侵入を避けるため、傾斜を変えて路線を設定している。これは東岸の支配面積を減らすけれども、ロスした地域の回復のための揚水が幹線水路のコストを増加させた。シクタ事業の右岸区域（34,270ha）、ベリーババイ事業の全域（40,000～53,500ha）はカルナリ事業で提案された東岸かんがい区域に併合される。

マスタープランの水収支において、カルナリ川は調整しないでも、カルナリ事業案のかんがい開発の年間かんがいのための十分な水を供給するには十分であると結論付けている。しかしながら、多目的開発案は、流量調整を除いて、関連するかんがいを価値あるものとして提案している。下流調整ダムは、シルトを含まない水の供給とともに、事業区域に必要な電力を供給できる。ダムは、上流の電力調整の直接の影響のために必要であるため、コストは電力開発に十分に配分できる。これは、事業で提案されているいくつかのかんがい開発の経済的実行の可能性を実態上改善するものである。イニシャコストは最小にされ、年間の用水供給からの高い農業利益が実現するまでの間、利益の流れと一致して投資資金の流れが維持される。このように、開発の経済的実行の可能性は、高い頭首工のコストがかかる二者択一の事業より急速な実行率の達成への依存をより少なくするのである。

(14) ベリーババイ　分水事業

カルナリ川の大きな支流であるベリー川にいれられた流れは、比較的短い（延長8㎞）トンネ

ルを経由し、隣接するババイ流域に分水されている。

2河川の標高差は 140m以上あり、ババイ事業案の分水施設から上流にあるババイ流域の発電所で低コストの水力発電の電力を発生させることができる。発電施設は王立バルディヤ野生動物指定地区内に設置されることとなっている。

ベリーババイ分水計画は、1980年代の初期から積極的に検討されてきた。この計画は、有効水位差 100mを利用する24,000kw開発と35㎥／s分水という内容のババイかんがい事業の世界銀行評価に含まれている。

分水された水は、バルディヤ郡の年間のかんがい4万haを開発することが見込まれている。不足水量の検討はマスタープランで指導されているが、十分な年間の作付のためには、わずかな不足量が指摘されている。（4万haに代わって、確実なかんがい面積として3万4千haを見込んでいる）しかし、モンスーン時期には、かなりの余剰がある。

ファーストサイクル調査では、ベリーババイ事業の4万ha案だけが考えられている。（ババイ川の左岸の15,000ha、右岸の25,000ha）セカンドサイクルでは事業の再構成として、次のような要素を考慮している。

○ ベリ川の月間90%最小流量は60㎥／sで、ベリ、カルナリ川の合流点と分水点の間にほとんど必要としない流量と思われる。これは、もっと大きな導水トンネルが建設できるならば、先の見積りよりも大きな面積の開発ができることを示している。

○ ババイとシクタかんがい事業の経済的分析は、これらの事業が供給水を増量しない範囲では経済的に限界であることを示している。

○ カルナリ多目的事業で提起された開発概要では、ババイ分水施設案から5km下流でババイ川を横断する左岸幹線水路を必要とする。

○ カルナリ事業は非常に大きく（支配面積 190,950ha）、非常に長い実施期間が必要とされる。個々の実行可能な事業から成る事業段階の適性は評価される。

○ カルナリ流域における水力発電事業の可能性調査の一部分として、ヒマラヤンパワーコンサルタンツ（ＨＰＣ）は、分水量 120㎥／s、発電14万8千kwという事業を含むような、ベリーババイ事業の大型版を見積もっている。この評価は、セカンドサイクルの経済性分析に使用する新たな費用の見積を規定している。

セカンドサイクル調査の間の再構成によって、事業は、ベリからババイ流域への分水量60㎥／sとなっている。ピーク操作によって起きるであろうかんがい分水問題を減少させるため、電力は、ＨＰＣ調査よりも低い設備能力を持った発電所で、 140mの落差により発生させるようになっている。マスタープランの水収支は、53,500haの支配面積の開発が可能であることを示している。この地域は、ババイとシクタのかんがい事業地域に、いくつかの区域を併せても十分な大きさである。

水の供給を増やすことによって、ベリーババイ分水事業は、カルナリ事業の左岸かんがいシス

テムのファーストステージとして考えられた。この概念のもとで、ベリーババイ分水は、ババイ川の東側のかんがい可能地を開発し、カルナリ頭首工の完成までババイ川の西側の開発を延期することとした。ババイ堰を起点とするババイ左岸幹線水路は、カルナリ事業の最重要施設として建設される。もう少しあとでカルナリ事業に全く一体化されるベリーババイ供給地域もすでに実施する準備ができていることは認められる。ベリ川の流れを放任することで、カルナリ多目的ダム（水位差約 200m）でより大きなエネルギーを発生させることができるが、これは、ベリーババイ分水トンネルを横断させることと、ババイ頭首工付近で、カルナリ左岸幹線水路をベリーババイで新設する幹線水路に接続することによって達成される。このような整理によって、カルナリ事業の東岸83,000haのうちの50,000ha以上の開発が、主たるカルナリ開発に先だって独立した事業のように進めることができる。

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4) ① DAILEKH DISTRICT ② 1 : 125,000 ③ 英文字、コンターなし、3色刷り
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⑤ カトマンドゥ市内マップショップ

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注1) ① 表題、② 縮尺、③ 仕様、④ 発行者、⑤ 入手先等

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