

Campbell, Foss & Buchanan, Inc.

was established in **1981** as an independent natural resources management consulting firm specializing in the fields of:

- Hydrogeological Investigations
- Real Estate Environmental Audits
- Hazardous Waste Investigations
- Ground Water Supply Projects
- Surface & Borehole Geophysical Investigations
- Geological Investigations
- Mine Dewatering & Depressurizing Projects
- Minerals Exploration, Valuation & Mine Development

Technical Qualifications

C,F&B offers the full scope of geological and hydrogeological services. A Senior Partner of Campbell, Foss & Buchanan, Inc. was a pioneer in the early efforts to control hazardous waste disposal and to develop detection practices in the early to mid 1970's. He was involved in the development of the initial EPA ground water regulations and related implementation.

C,F&B has company-wide expertise in investigating a wide variety of subsurface contaminants and in their detection and removal, if feasible.

C,F&B has selected experienced laboratories to conduct the necessary analyses on soil and underground water, including asbestos and storage tank tightness testing. Special procedures are employed to ensure sample integrity and the appropriate chain of sample custody. C,F&B investigations are supervised and directed by Certified Professional Hydrogeologists and Geologists familiar with the local conditions and history. Client-consultant confidentiality is maintained according to the highest of ethical standards.

Personnel

Michael D. Campbell, President and Senior Hydrogeologist/Geologist of C,F&B, is widely known by industry and government for his work in hydrogeology on topics ranging from water supply development through hazardous waste characterization and remediation to vadose flow in heap-leach mining in

the past few years. In the early 1970's, and in cooperation with Dr. Jay H. Lehr, Mr. Campbell was the founder and first Director of Research of the National Water Well Association, Technical Division's Research Facility in Columbus, Ohio. The Facility was subsequently moved to Rice University in Houston, Texas. Mr. Campbell has produced more than 120 major reports and publications over the past 22 years including the popular texts: Water Well Technology (by McGraw-Hill: 1973), and Geology of Alternate Energy Resources (by Houston Geological Society: 1977). He is a graduate of The Ohio State University (1966) and Rice University (1976) with degrees in geology/hydrogeology. Mr. Campbell is a Certified Professional Hydrogeologist (#480) and a Certified Professional Geologist (#3330) and has served on numerous technical committees. He has presented many technical short-courses on a variety of topics and is a member of numerous technical societies.

Ted H. Foss, Chairman and Senior Geologist, is also widely known throughout industry and government for his work in astronaut training, resource exploration, management and development. In the mid 1960's, Dr. Foss served as Chief, Geology and Geochemistry Branch of NASA and personally supervised the astronaut training program in preparation for the numerous moon landings and subsequent sampling programs conducted during the period. In the 70's and 80's, he served as a senior consultant to domestic and international minerals and mining companies. Recently he was the executive officer for a heap-leach mining operation in Nevada. Dr. Foss has produced more than 50 major reports and publications over the past 30 years. He is a graduate of The University of Illinois (1956 and 1958) and of Rice University (1964) with degrees in geology/geochemistry. Dr. Foss is a Certified Professional Geologist (#6393) and is a member of many professional societies.

Other senior and intermediate independent personnel join the C,F&B team as merited by the project. Dr. H. C. Clark, Rice University, provides input on geophysical projects. Mr. Kelly Sommers, consultant, provides input on flow systems. Mr. Robert N. Arrington, ex-Texas Eastern executive, provides assistance on site assessment projects. When the need arises, other specialized consultants are engaged for input on physical and chemical engineering, groundwater modeling, regulatory matters and other subjects on the frontier of development.

Project Qualification

C,F&B personnel are involved in projects in a number of possible ways:

1) To provide overall project management in terms of project formulation, design, implementation, sub-contracting, accounting and report presentation,

2) To provide a source of research and input for a larger project to evaluate special problems, and

3) To provide quality control/quality assurance for projects at various stages of development.

Projects range from a small, isolated spill assessment to retrofitting an existing inappropriate remediation system installed in a major refinery, to eliminating loose language in a client report of investigations. Matching appropriate technology with existing conditions is a necessity if a remediation system is to operate efficiently and reliably over the design life. Selecting the appropriate sampling and storing methods is often overlooked during project operations. Probably the most underrated activity is pump selection, both type and configuration, not to mention the type of associated wiring or fittings.

Definitions In Hydrogeochemistry

In other projects we have noticed that two types of chemical analyses of ground water are often inter-mixed indiscriminately. The most common type is the analysis made to establish the character of the water as it will be used. These are water-quality analyses. The other type is rather rare for it strives to reveal the chemical character of the water in the subsurface. These are hydrogeochemical analyses.

If the water sample represents only a small portion of the underground flow system, and if the sample did not age significantly before it was analyzed, it can be considered a hydrogeochemical analysis. Some water-quality analyses meet these criteria but uncertainty would still prevail. We can predict the chemical character of the water as it will be used, if we know the chemical character of the water as it exists underground.

The inverse is not necessarily true. We can use hydrogeochemical data, coupled with ground-water age determinations obtained by isotope methods, to interpret ground-water flow patterns because the ambient water chemistry in a particular part of the flow system depends on such factors as:

- 1) the antecedent ground-water chemistry,
- 2) residence time of the ground water,
- 3) the chemical composition of the ground-water system,
- 4) the temperature-pressure relationships in the continuum that control water-rock reactions, and
- 5) sampling procedures.

Because ground-water flow systems are three dimensional and flow may be across bedding or stratigraphic units, as well as parallel to them, the chemical character of water in a formation does not necessarily reflect chemical changes due exclusively to flow through that formation. Conversely, local, intermediate, and regional flow systems can in some places be identified by their chemical characteristics, even though all flow may be essentially horizontal.

Analyzing Ground-Water Flow Systems

For investigation purposes, we assume that the ground-water flow systems of any drainage basin were in dynamic equilibrium before man's modifying activities began. We assume this for two reasons: 1) the storage-mining concept is in many respects simply a special case of the dynamic equilibrium concept; that is, it is the case where natural recharge/discharge is negligible; and 2) when our concern is with the potential flow paths that a pollutant might travel if it were to enter the flow system, the storage-mining concept is inadequate.

From the discussion of the ground-water flow system concepts, the factors we often need to quantitatively describe the ground-water flow systems of any region reduce to the following: 1) the spatial distribution of the hydraulic properties of the rocks (the flow continuum); 2) the shape and configuration of the water table and its temporal variations; 3) the spatial and temporal distribution of head; 4) the definition of recharge and discharge areas (both natural and those due to man's activities); and 5) the spatial and temporal distribution of the properties of the fluid (water). Only with these data can we develop hydrologic budgets, describe the consequences of changes in the systems, predict the yields of recovery wells, and otherwise deal with problems that relate to quantities. The integrity of these data in many projects today are not acceptable.

To deal with those questions that relate rock-water chemical reactions and the direct impact of pollutants or contaminants on the flow system, the

FIELD OPERATIONS

Combined with the above analyses, water samples are also analyzed while in the field for temperature, pH and specific conductance. VOCs are screened in the field by subjecting surface soil samples and/or shallow auger samples to a portable photo-ionization meter or organic vapor analyzer. This procedure guides subsequent sampling.

THE NEED FOR A SECOND OPINION

In most large real estate transactions, a hydrogeological/geological consulting firm is engaged to conduct the site assessment work. A second opinion is usually sought from another consulting firm to independently assess the conclusions and recommendations for future work recommended by the primary consultant.

THE PROFESSIONAL FOR THE JOB

It is extremely important that site assessments are undertaken by firms having Certified Professional Hydrogeologists and Geologists. Civil engineers, for example, are not qualified to undertake such investigations just as hydrogeologists and geologists are not qualified to build bridges and highways.

There is a critical shortage of qualified senior hydrogeologists in the U.S. today, while engineers, especially petroleum and civil, are available in abundant numbers. This creates problems for some engineering firms.

C,F&B ENVIRONMENTAL ASSESSMENTS

- C,F&B has expertise in a wide variety of sub-surface contaminants and their detection.

- C,F&B also has selected experienced laboratories to conduct the necessary analyses on soil and underground water, including asbestos and storage tank tightness testing.

- C,F&B investigations are performed by senior, independent, Certified Professional Hydrogeologists and Geologists familiar with the local conditions and history.

- C,F&B provides all the required services including: soil sampling, augering and boring, monitor wells, aquifer analysis, borehole geophysics, computer modeling, and reports of investigations containing clearly stated conclusions and recommendations concerning remedial activities, if any.

- Michael D. Campbell, one of the Senior Partners of C,F&B was a pioneer in the early industrial/academic efforts to handle hazardous waste disposal and to develop detection practices in the early 1970's. He was involved in the development of the initial EPA regulations and related implementation. He is recognized today world wide for his work published by McGraw Hill on well technology and on hydrogeology and geology in general.

**Call us
for more information
on how we can help
with
the new environmental requirements
of your
real estate projects.**

(713)583-7173

REAL ESTATE ENVIRONMENTAL AUDITS FOR YOUR BUSINESS AND INVESTMENTS

by

Campbell, Foss & Buchanan Inc.

Property owners selling commercial or residential real estate may be liable for any clean-up of contaminated soil or underground water months or years after the sale has been consummated. To offset this risk, a comprehensive environmental audit or assessment of the property by experienced, professional hydrogeological personnel prior to sale is advisable. As part of prudent business practices, buyers are now under increasing pressure to require a favorable environmental assessment if the sale is to be closed. In the broader sense, however, the commercial real estate world, including anyone involved in buying, selling, financing or insuring real estate, has over the past few years been faced with a serious new problem: the possibility of dealing with contaminated property. Legislators have assumed the task of adopting fairly drastic measures to insure the clean-up of contaminated areas in as brief a time as possible.

LAWS & REGULATIONS

Numerous laws and regulations on both the state and federal level have been passed which assign liability for environmental damage to various parties deemed responsible for that property, including owners, managers, and in some circumstances even lenders. The costs of clean-up and restoration incurred as a result of such liability can be staggering and may in some cases exceed the property's value.

The most publicized source of environmental liability is federal law, particularly the statute known as "CERCLA" (Comprehensive Environmental Response, Compensation and Liability Act) or "Superfund". It imposes liability upon persons and organizations responsible for creating environmental problems, including owners, operators, and lenders

under certain conditions (if the lender is a participant in the activities of the owner or operator of that property, or if the lender purchases contaminated property at a foreclosure sale, for example).

Liability under CERCLA is imposed without regard to fault and any responsible party may be held liable for all cost and expenses associated with the site. Owners may be liable even if they did not cause or contribute to any release of a hazardous substance at the site. One of the few exceptions to liability under the CERCLA statute is the "innocent landowner" defense. This protects purchasers who have no knowledge of environmental problems despite "all appropriate inquiries into the previous ownership and uses of the property consistent with good commercial or customary practice," taking into account "the ability to detect contamination by appropriate inspection."

Compliance with laws requiring the performance of a site assessment should satisfy the innocent landowner defense. The purchaser needs to have the site history investigated by an experienced, hydrogeological firm to determine whether soil and groundwater sampling is necessary. If there is reason to believe that hazardous substances have been used, stored or disposed on the property, soil sampling and possibly ground-water sampling probably is necessary to invoke the protection of the innocent landowner defense. Other federal statutes concerning environmental liability are:

1) Resource Conservation and Recovery Act of 1976 ("RCRA") which imposes a "cradle-to-grave" system of regulations of the generation, transportation, storage and disposal of hazardous wastes, which can be a source of liability for property owners through cleanup orders and penalties.

2) Federal Water Pollution Control Act ("FWPCA") which creates liability for discharges into navigable waters of the United States. To avoid liability a purchaser should conduct an investigation to reveal potential hazards as soon as possible, and take actions to prevent discharges as soon as possible after discovery of the potential hazards and assuming control of the property.

3) Hazardous Materials Transportation Act, the Safe Drinking Water Act, the Coastal Zone Management Act, the Occupational Safety and Health Act, the Emergency Planning and Community Right-to-Know Act, the Federal Insecticide, Fungicide, and Rodenticide Act, the Toxic Substances Control Act, the Marine Protection, Research and Sanctuaries Act, the National Environmental Policy Act, the Noise Control Act, the Endangered Species Act, and the Clean Air Act.

State and local laws are an increasingly important source of liability.

Forty-one states and one territory have some type of law creating a funding mechanism to clean up waste sites. Several states have statutes that give state environmental authorities a lien on contaminated property (Tex. Rev. Civ. Stat. Ann. Art. 4477-7, S 13 (g)). This allows the state to impose a lien on property that is cleaned up by the State for the cost of cleaning up contaminated property.

The implications of these laws (and court decisions holding that lenders are not excepted from environmental liability) for those involved with commercial real estate are that screening procedures have become necessary to identify problems associated with a property before becoming involved with and potentially liable for it.

Environmental site assessments are designed to perform that screening and to detect the presence of environmental problems before the property changes hands. Most lenders now require a site assessment in connection with loans secured by commercial or industrial real estate. Many real estate firms are not aware of the potential liability they may be introducing to transactions they are performing for clients.

SITE ASSESSMENTS

Site assessments should be conducted by experienced, certified hydrogeologists. They will begin the procedure by asking a series of questions designed to provide history and background information on the property and determine the necessity and extent of further investigations. Based on the answers to these questions and a survey of the public record the property will be placed in one of two categories:

- 1) a walkover assessment with little or no sub-surface investigation required; or
- 2) a walkover assessment with extensive sub-surface investigations and environmental sampling.

COST OF ASSESSMENT

The cost of the site assessment will be determined by the extent of investigative effort required. The second category of assessment may cost much more than a conventional walkover assessment, two-thirds of which cost is represented by soil analyses and by monitor well construction and ground-water sample analyses by an independent, certified hydro-

geological consulting firm and laboratory. Costs start at approximately \$4,000 and go up as the extent of contamination found increases.

POTENTIAL PROBLEM SITES

Obvious potential problem areas are properties that once contained or presently contain or abut: service stations, auto garages, fleet operators, pest control companies, hardware or garden supply companies, farms, landfills (garbage dumps), roofing companies, junk yards, dry cleaners, schools, painters, machine shops, industry, or septic systems.

The identification of the contaminating characters in the soil and underlying sediment, rock or ground water of these potential problem properties may not be obvious to the untrained observer, especially after the surface has been reworked by earth-moving equipment. The soil and the ground water below or adjacent to the property may contain telltale traces of hazardous materials.

THE HAZARDOUS WASTES

A broad range of volatile organic chemicals (VOCs) are usually tested during preliminary investigations because of their toxic effects on humans and critters. EPA has established maximum limit guidelines. The most common VOCs tested, however, are:

<u>VOC</u>	<u>EPA Maximum(ppb)</u>
Benzene	40
Toluene	5,000
Xylene	440
Ethylbenzene	430

The metal elements of particular interest in drinking water in excessive quantities are presented below. Their maximum limits have been established by EPA and are usually tested during preliminary investigations:

<u>Metal Element:</u>	<u>EPA Maximum(ppb)</u>
Arsenic	50
Selenium	45
Chromium	120
Cadmium	5
Zinc	NS
Lead	20
Barium	1,500
Copper	1,300
Silver	NS
Mercury	3

NS= Limits not yet established by EPA.

list must be extended to include: 6) the spatial distribution of the mineralogy and petrography of the rocks, and the reactions that potentially could take place between the rocks and the moving solution; 7) the spatial and temporal characteristics of the solution; and 8) the spatial distribution of any special properties of the rocks not normally encountered. This eight-item list forms the basis for developing a preliminary model of the flow systems.

In our experience in projects, most hydrogeologic investigations deal almost exclusively with only the first five items. However, the following questions must also be addressed and incorporated into the project from initiation through completion:

- 1) is the number of measurements sufficient?
- 2) were the properties measured at an appropriate scale?
- 3) do the measurements actually reflect conditions in the flow system?
- 4) How do existing measurements differ from the data ideally required?

Ground-Water Monitoring

For most project purposes, monitoring means the routine, rigorous, and systematic measurement of some property of a ground-water flow system, either physical or chemical. Two types of monitoring programs exist.

The most common program involves measurements made:

- 1) at regular intervals,
- 2) at the same point,
- 3) in the same way,
- 4) to the same precision, and
- 5) with an accuracy sufficient to detect significant differences.

Programs adequate for one project may be inadequate for others. For example, an agency of the federal government measures quarterly the tritium concentration of precipitation samples collected at selected locations in the United States. The purpose of the program is to compare ambient concentrations with human-health hazard levels so measurements to the nearest 100 picoCuries per liter are adequate. But for ground-water programs, we need two significant figures' precision with an accuracy of about 5.0 picoCuries per liter. Clearly, data collected to establish the human-health hazard are often unsatisfactory for regional ground-water purposes. The reverse is also true and the needs of the sampling and analysis programs are project specific.

The second type of monitoring program involves taking periodic measurements of some parameters at random points and then drawing contours to depict the parameters' distribution. The data can be handled statistically, spatial-temporal relations can be expressed, and future relationships predicted. Periodic random-point measurements show patterns and identify the extent of some on-going change. They serve to state the case, but for a variety of reasons they often obscure the details.

Classification of Ground-Water Monitoring System

Ground-water monitoring systems are required because someone somewhere wants to know something for some reason. We must therefore classify ground water according to:

- 1) who wants to know,
- 2) why they want to know,
- 3) what they want to know,
- 4) what they expect to find out, and
- 5) what political or engineering consideration motivated the initiation of the monitoring program.

We may also classify ground-water monitoring systems according to stress and the expected response to that stress. Stresses may be classified as: (a) direct or indirect, (b) simple, compound, or complex, and (c) short term, intermittent, or continuous.

Stress of Environment

Stress is any activity that forces a change or response in the environment (i.e., the ground-water system). Pumping wells are the most common stress. Other common stresses include mines, feed lots, sanitary-waste disposal facilities, reservoirs, septic tanks and tile fields, salt water disposal ponds, and irrigation.

Virtually every change in land use generates a stress on the ground-water flow system. The stresses may be unique, generating specific, expected and easily measured changes. Or, as is the case in many areas, so many stresses occur that the discrimination of individual responses becomes difficult and may even be impossible to define.

Computer Modeling

Computer modeling is of growing importance to many types of ground-water projects. Large, expensive main-frame computers are no longer required to

effectively model a dynamic project. A comprehensive understanding of the numerous models available, and their disadvantages, is of paramount importance.

A ground-water model is the conceptualization of an underground-water flow region, i.e. where the water flows from and to. We derive our conceptualization of the ground-water flow system from appropriate hydrologic and geologic data.

A mathematical model in hydrogeology includes a flow equation and boundary conditions. Typical limitations of boundary conditions are: no flow across the boundary, constant head (water-level) at the boundary, or constant flow across the boundary. An infrequent boundary condition is a variable flow rate across the boundary.

The mathematical model describes the conceptual ground-water model in mathematical terms. With mathematical expressions for the ground-water model we can predict water-level responses in the flow domain because of the effects of pumping wells.

Typically, we can use three methods to predict water-level response: analytical, numeric, and resistance-inductance-capacitance (RLC) analog. With the widespread availability of high-speed computers the RLC analog method is rarely used now. The analytical techniques derive an equation that predicts water levels anywhere in the model domain. The numerical methods predict water levels at isolated points in the flow domain. The differences between analytical and numerical models are described below.

Both methods are based on solving the ground-water flow equations with boundary conditions. The analytical method yields a formula from which predictions are made, while the numerical method makes predictions for particular problems. For most cases the flow-domain parameters (hydraulic conductivity and storage) and the boundary conditions are too complex to yield an analytical solution. In a few simplified cases though, the flow domain and the boundary conditions are simple enough that we can obtain an analytical solution. The numerical method approximates the flow domain and flow equation at specific locations. When given flow-domain parameters and boundary conditions we apply a numerical technique and can predict changes in water levels.

We prefer to use an analytical solution if our conceptual ground-water model justifies it. We can justify an analytical method in only a few cases and hence we use numerical methods for most regional

ground-water models. The numerical mode can be used when the ground-water system has different regions of hydraulic conductivity or storage, or where the boundaries of a system are irregular. In general we use a numerical model for most ground-water systems only for the simple cases. For quick, preliminary calculations we resort to analytical methods, but the choice depends on the project.

A number of numerical techniques exist for solving ground-water flow problems to predict water level by computer. Four common techniques are: finite difference method (FDM), integrated finite difference method (IFDM), finite element method (FEM), & boundary element method (BEM). The difference between these techniques lies in the way the flow equation is discretized. For the most part one method is no better than any other method; however, the IFDM, FEM, and BEM usually take into account more of the surrounding points than the FDM. For very complicated flow systems the IFDM and FEM are used almost exclusively. The BEM is relatively new to hydrogeology and has not yet gained as widespread acceptance as the other methods.

The quality of the prediction we get from a numerical model depends on the integrity of the data available for analysis. With good data and a calibrated model (a calibrated model is one that mimics past water levels given the pumping rates in the past), the prediction is useful for about twice the length of the water-level history of an area. With bad input data all you get from the model are incorrect results.

Pledge of Diligence, Integrity and Confidentiality

We give you our solemn pledge that we will commit our best efforts in any project we undertake on your behalf. We also pledge that we will retain our professional objectivity on your project by giving you our unrestricted opinions, conclusions and recommendations concerning the assigned tasks. By applying good science and technology with effective management, we will provide you with the best possible information upon which prudent decisions can be made.

**For more information on how
C,F&B
can assist you, please inquire further**

(713) 583-7173