BESST INC.

GLOBAL SUBSURFACE TECHNOLOGIES

Water Supply Well 診断サービス

DyeTracer / HydroBooster Services

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BESST ダイトレーサ・ハイドロブースターシステムは流速プロファイルと汚染物質の深度測定によって効果的かつ経済的に運営管理を可能にするサービスです（産業揚水や農業用水など）。BESSTの予測診断管理プログラムにより、水質管理や観測井のパフォーマンスを既存のポンプを取り除くことなく、診断することができます。小径ポンプ (2.54cm以下）はほとんどの井戸に新・既存のポートへアクセスすることが可能です。診断サービスは正確な観測井の特徴やパフォーマンスを提供します。

ハイドロブースターシステムは汚染物質の場所と濃度比を正確に示すシステムとして使用されます。サンプルは深度によって採取することが可能です。

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ダイトレーサシステムは排他的ライセンスのもとBesst inc にて操作・管理されている。染料を使用し、深度による流速を測定することが可能になった（スピナーログや他の手法に匹敵する精度）。少量の染料（EPA・NSF認証）を井戸の投入することにより、そのインターバルからサンプル深度の生産量を算定する。地表からのリターン比率から正確な流速プロファイルを行うことができる。

ダイトレーサシステムは染料を投入し、戻ってくる時間を計算して観測井の診断を行う。

蛍光光度計は染料の濃度を感知する（PPB）。

リアルタイムでデータは記録されていく。

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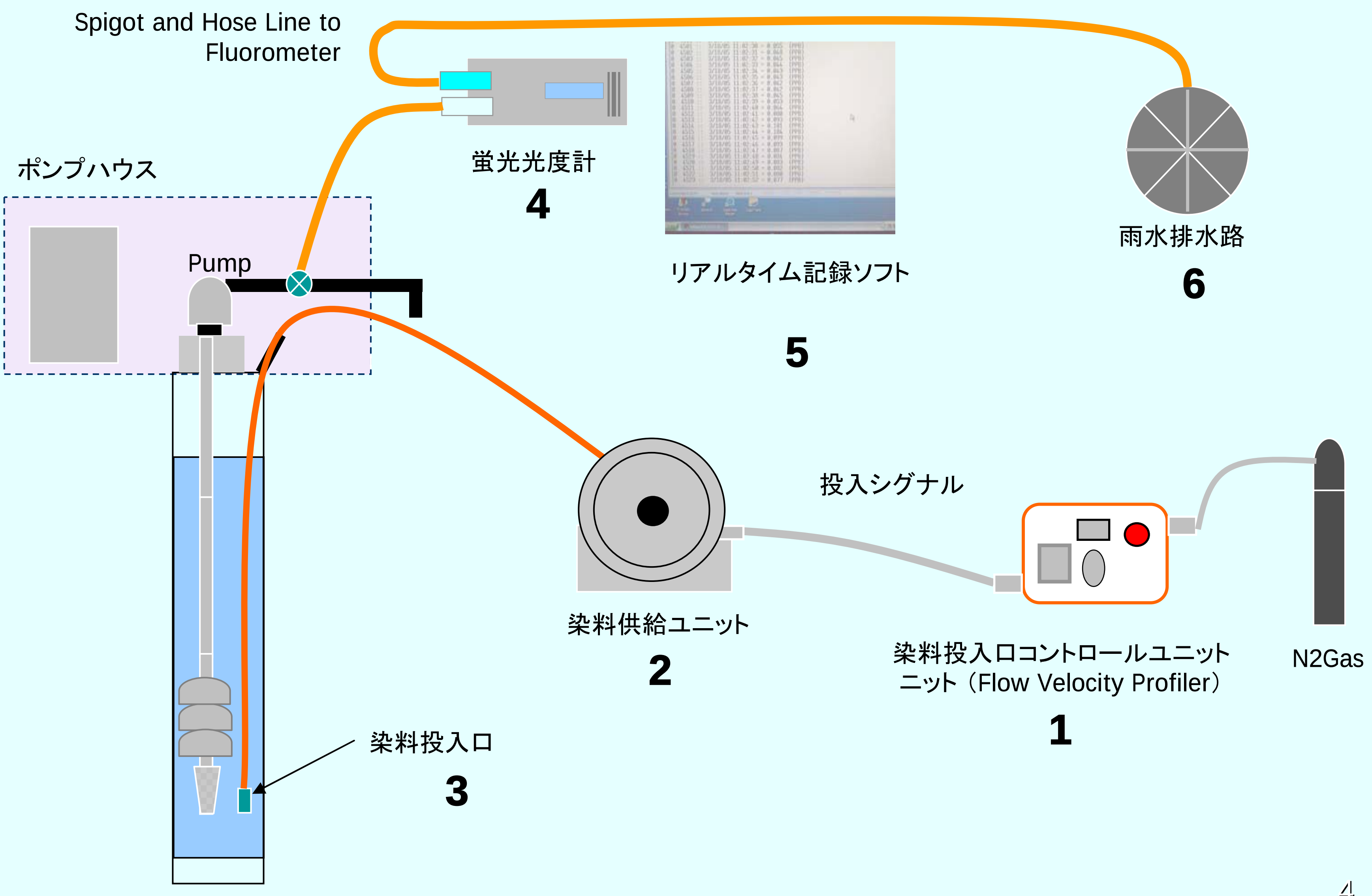

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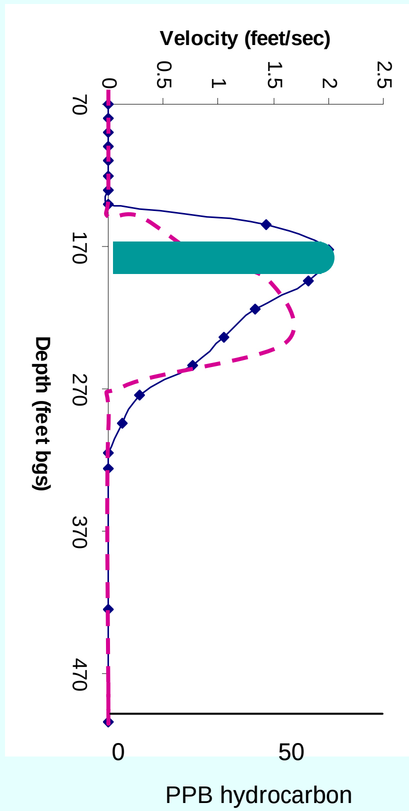
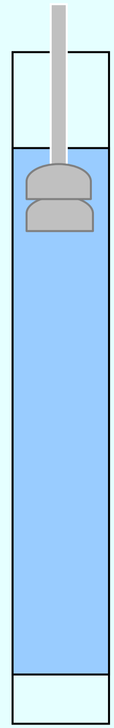
**流速解析計算例
（GPM）**





<u>DATA</u>

a. Flow Meter = 1,500 GPM

b. Flow velocity at 170 ft. BGS = 50 seconds (as determined by peak return time for rhodamine dye to fluorometer).

c. Flow velocity at 190 ft. BGS = 64 seconds (as determined by peak return time for rhodamine dye to fluorometer)

d. [Cross section area of well] x [distance between sampling points (20 feet)] = 209 gallons.

<u>CALCULATION</u>

209 GPM / (14 Secs/60 Secs) =

209 GPM / 0.23 = 908.6 GPM

908.6 GPM / 1,500 GPM = 60%

<u>CONCLUSION</u>

Therefore, 908.6 GPM or approximately 60% of total water production is derived from 170 to 190 feet BGS, as indicated by the green bar.

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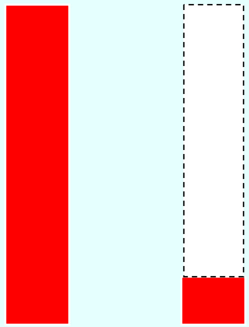
Well Economics – Case Study
下記の5つのタンクはそれぞれ22000lbs（約9979kg）の炭素。20日おきに、これらの活性炭素は上層部に炭水素となって、結果的に汚染物質になる。

給水事業者は約50000ドルの費用をかけて炭素除去を依頼する。年間の費用は912,500ドルにも及び、この際の労働費などは含めれていない。

BESSTのハイドロブースターシステムは汚染物質のメインゾーンに設置され 、ダイトレーサによって得られたデータを使用し分布解析を行う。

$912,500 / yr. for Carbon Replacement



$100,000 per yr. BESST 診断サービスによるコストダウン結果

サンプリングと流速解析によって得られたデータをもとに高低プロダクション・汚染ゾーンの診断を行う。給水業者は診断を基に高生産水位・非汚染域にポンプを設置移動させる。結果、1年に2回の炭素取替えになり、812,500ドルのコスト削減につながった。

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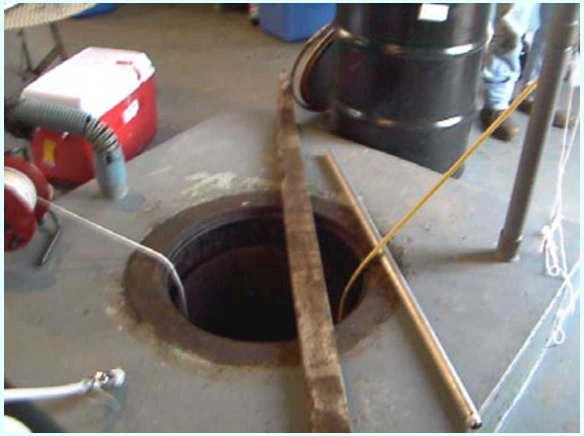
これらの写真は従来型の通常行われる揚水解析プロファイルの例。

ポンプを取り除くのは手間とコストがかかる。

BESSTのダイトレーサ・ハイドロブースターは既存のポンプをとり除かず操作・サンプリングが可能。



U.S. Geological Survey Combined Well-Bore Flow and Depth-Dependent Water Sampler

The U.S. Geological Survey has developed a combined well-bore flow and depth-dependent sample collection tool. It is suitable for use in existing production wells having limited access and clearances as small as 1 inch. The combination of well-bore flow and depth-dependent water-quality data is especially effective in assessing changes in aquifer properties and water quality with depth. These are direct measures of changes in well yield and ground-water quality with depth under actual operating conditions. Combinations of other geophysical tools capable of making these measurements, such as vertical-axis current meters used with wire-line samplers, are commercially available but these tools are large and can not easily enter existing production wells.

BASIC OPERATING PRINCIPLES

The U.S. Geological Survey device is a high-pressure hose equipped with valves for dye injection and sample collection. The hose is mounted on a reel for deployment, retrieval, and storage (fig. 1). The hose can be used to collect velocity-log data and, after cleaning and decontamination, the same hose can be used to collect depth-dependent water-quality data. Accessories, such as a Teflon® hose extension, are available for collection of organic compounds.

Velocity-Log Data

The equipment is used to obtain flow data within the well bore under pumping conditions using a technique we named the 'tracer-pulse method.' When operated in this mode, the hose is filled with fluid containing an easily measured tracer, such as water colored with Rhodamine dye. The hose is lowered to a known depth in the well (d_1) and a pulse of the tracer is injected into the water column. The travel-time of the tracer to a detector on the surface is measured (t_1). If Rhodamine dye is used, a commercially available fluorimeter is used to measure the arrival

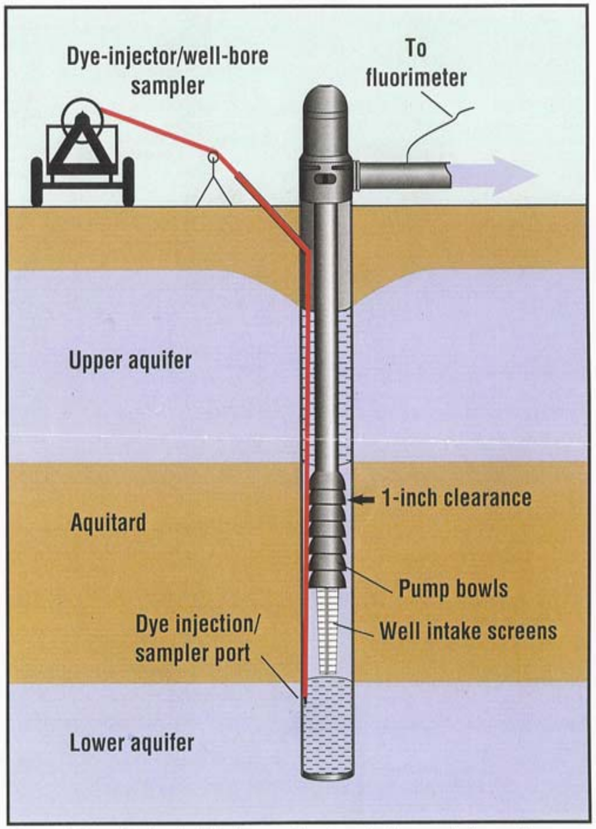


Figure 1. Example of typical deployment in a deep-turbine production well.

of the dye at the surface. The hose is then lowered to the next depth (d_2), another pulse of dye is released, and the travel-time is measured (t_2). The velocity is calculated as the difference in the travel-times. Assuming piston flow, the flow rate (Q), given a known well radius (r), is calculated using the following equation:

$$Q = (V\pi r^2) \quad \text{where: } V = (d_2-d_1)/(t_2-t_1)$$

A series of injections at different depths is done to construct a velocity profile for the well. The velocity profile can then be used to guide the collection and interpretation of depth-dependent water-quality data.

U.S. Department of the Interior
U.S. Geological Survey

Depth-Dependent Water-Quality Data

To collect a water-quality sample from a given depth in the well, the hose is pressurized to greater than the hydrostatic pressure at that depth and lowered into the well. When the sample depth is reached, the hose is vented at the surface and water from the well at the sample depth enters the hose. The hose is retrieved and the sample expelled from the hose under pressure. The process is repeated at several depths to complete a water-quality profile within the well. If the concentrations of a constituent at the first sample depth (C_1) and the second sample depth (C_2) are known, the concentration in water entering the well from the intervening water-bearing zone (C_a) can be calculated from the water-quality profile and the velocity-log data:

$$[(C_1Q_1-C_2Q_2)/Q_a] = C_a$$
$$\text{where } Q_a = (Q_1 - Q_2)$$

This calculation assumes conservative mixing and conservation of mass.

APPLICATIONS

The data shown in figure 2 are from a deep production well in a complex multiple-aquifer system. These data illustrate changes with time in the chloride concentration of water entering the well at depth and changes with time in the distribution of flow into the well. Because changes in well yield and water quality measured at the surface were small, these changes would not have been detected using conventional sample collection methods which are a composite of all the water flowing into the well. A comparison of data from a velocity log using a conventional spinner tool and a velocity log using the tracer-pulse method also is shown in figure 2. The tracer-pulse method correctly identified the most important water-yielding zone and the depth below which almost no water enters the well. Neither of these important hydrologic features could have been identified on the basis of indirect data, such as a resistivity log (fig. 2).

The combination of velocity-log data and depth-dependent water-quality data is an especially effective data set for hydrologic interpretations. Specific applications for data collected using this approach include:

(1) Identification of changes in ground-water quality and well yield with time.
(2) Identification of different water-bearing units with depth.

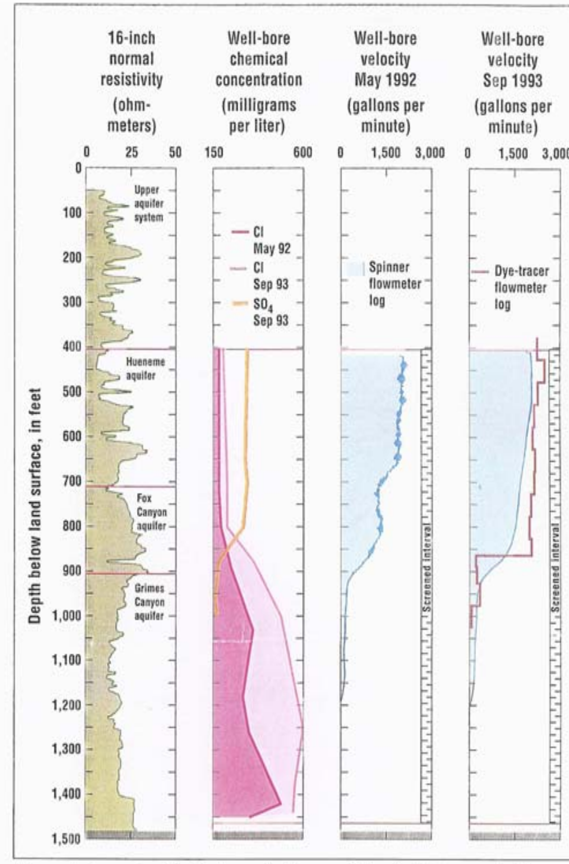


Figure 2. Example of depth-dependent flow and chemical data sampled from a deep production well.

(3) Identification of changes in natural ground-water chemistry with depth.
(4) Identification of man-made or natural contaminants with depth.

Although the applications described here are primarily for production wells, the approach also can be applied to observation wells. This approach may be especially useful to assess the performance of wells used for remediation if contaminants are stratified within the aquifer.

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