HYDROFRACTURING.

PRELUDE: To tap ground water, the ground water abstracting structures like bore wells/ open wells are drilled / dug. Bore Wells have been regarded as adequate safe source of drinking water. Even after scientific location of bore well points in hard rock areas, some bore wells yield poor discharge or fail to yield water. The percentage of failure varies from place to place which in turn depend upon the geology, hydrogeology, rainfall pattern, poor hydrostatic characteristics of fracture systems. Considering the cost factor involved in drilling bore wells, rejuvenation of failed wells through some technique is thought off. The innovative technology of ''Hydrodrofracturing'' is a new approach to revitalize the bore well to improve the yield by applying water pressure in the bore wells The hydrofracturing technique was first used in oil wells to increase oil and gas production. Hydrofracturing technology was first successfully used in India in early 1984 by an NGO in Madhya Pradesh.

HARD ROCK AQUIFERS; There are two types of rocks namely hard rock and sedimentary rocks. In hard rock terrains the ground water occurs in the weathered mantle, joints and fractures present in them. An aquifer may be defined as a saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients. The secondary porosities ie. the joints and fractures in hard rock act as conduits to transmit water which constitute the aquifer system. Generally in hard rock areas ground water occurs under unconfined conditions [Pheratic aquifer].

REJUVENATION OF BORE WELLS: The basic reason for the failure of bore well in hard rock terrain is the poor hydrological characteristics of fracture system. The process of revitalizing and rehabilitating of failed wells may be called as rejuvenation there by the failed wells are made to yield water. The poor yielding and unyielding bore wells can be rejuvenated by two techniques. One is the blasting technique where in the fracture system are developed and widened by blasting with dynamite explosives [electrical detonator] which requires lot of precautions and safety measures and the other technique is hydrofraturing where in water at high pressure is injected in the failed wells to break up fissures, cleans away mud and other impurities thus making it to contact with adjacent water bearing bodies.

HYDROFRACTURING TECHNIQUES: Hydro fracturing is a well development process that involves injecting water under high pressure into a hard rock formation in the well. This is intended to increase the size and extent of existing bed rock fractures pumping water into the fractures at high pressure as high as 3000 psi and flow rate at about of 85 gpm. Hydraulic pressure is applied to an isolated zone of bore well to initiate and propagate fractures. The water injected at high pressure break up fissures and joints, cleans away all impurities there by the permeability of rock formation is increased [Figures- 2 & 3].

PRINCIPLES OF HYDROFRACTURING : The basic principle behind hydrofracturing technique is PASCAL's law, which states that when the hydraulic pressure is applied in any closed body, it acts in all directions and it is equal at all points. When the high pressure water injected in the isolated section of bore well, the hydraulic pressure acts equally in all direction. The injected water follows the least resistance path and therefore the initiation of fractures or opening of the fractures takes place in the weathered zone.

Fig-1, Hydrofraturing Unit.

HYDROFRACTURING EQUIPMENT: The hydrofracturing technique is an important tool to improve the yield of bore wells. The process of hydrofracturing is carried out by means of special equipment. The entire set of hydrofracturing equipment is called the hydrofracturing unit [Fig-1]. The hydrofracturing unit mounted on a carrier is provided with equipment intended to carryout two types of processes in field especially the Aquifrac and Aquitest of bore wells. In addition the water tanker is provided to transport and store water. The hearts of the unit are high pressure plunger pump and the packer. The water injection pump plays a prime role in the hydrofracturing process. which is intended to initiate fractures overcoming the insitu stress of rock formation. The discharge rate of the pump and treatment time control the fracture length. The packer assembly is intended to seat off the bore well at predetermined section. There are two types of packer assemblies viz, single packer assembly and double packer assembly.

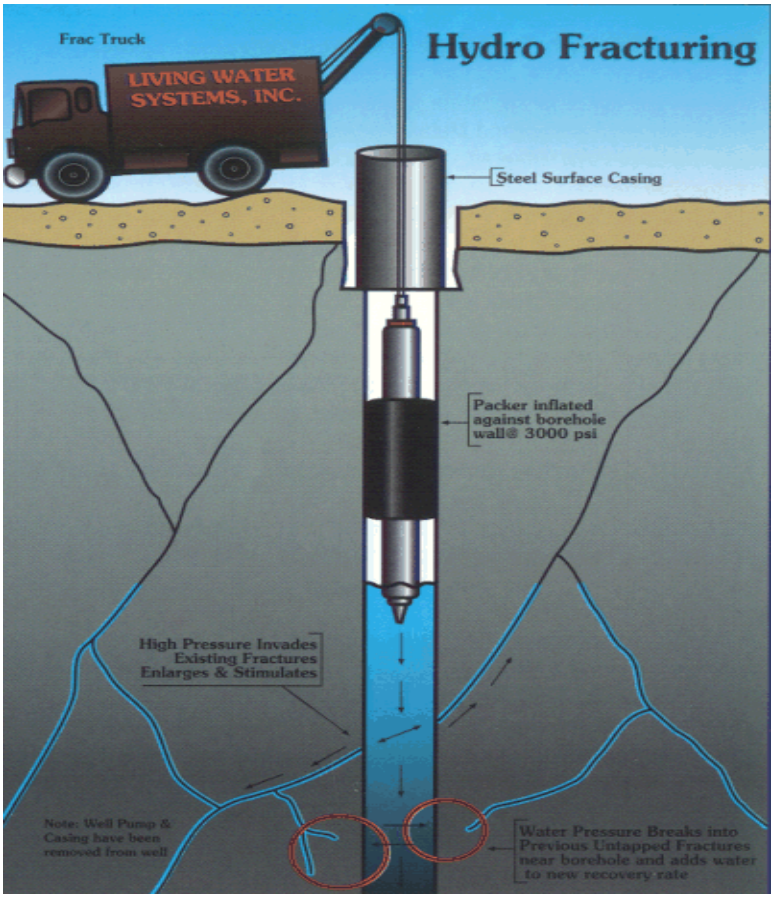

Fig- 2, Hydrofracturing technique.

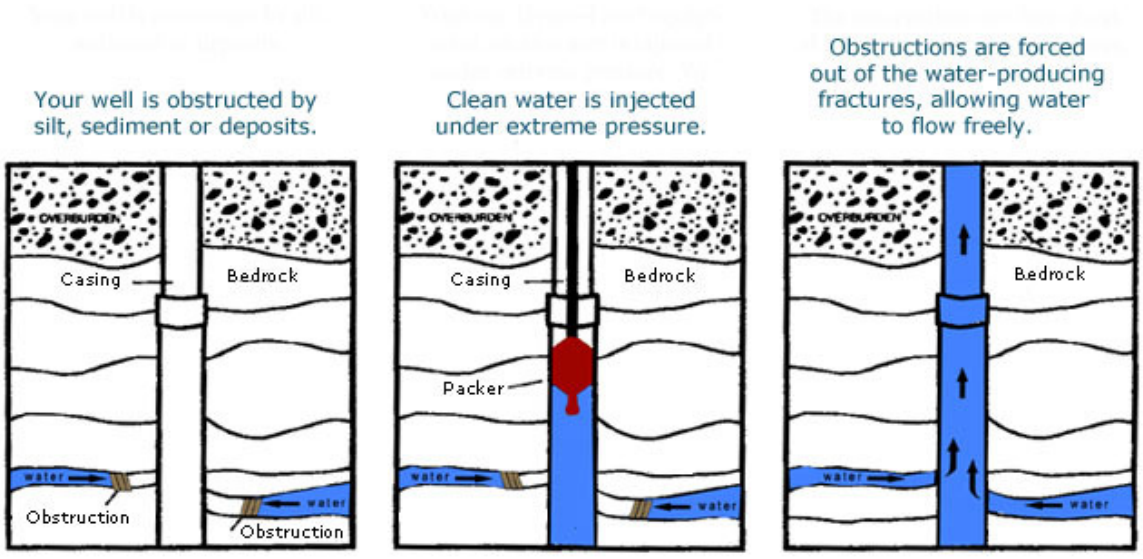

Fig- 3, The impact of hydraulic pressure.

PROCEDURE AND OPERATION OF HYDROFRACTURING UNIT;

- Scientifically studying the lithology backed up with electrical logging.
- Demarcation of weathered zones and the aquifers.
- Measurement of static water level and yield of well before fracturing.
- Entering these basic data.
- Lowering of packer to the selected depth and fixing by applying hydraulic pressure [Fig-5].
- Opening the booster pump and injection pump to inject water in the isolated down the hole section.
- Noting the minimum and maximum pressure during hydrofracturing shut.
- Measuring water intake during operation.
- Releasing the packer and setting down in the next selected section.
- Carrying out hydrofraturing @ number of sections selected.
- Pumping out the water intake and measuring the post fracturing yield.
- Entering all these field data.
- Conducting electrical logging after fracturing to study the effect of hydrofraturing.

HYDROFRACTURING OPERATIONS IN THE FIELD: The normal procedures for hydrofracturing operation are, Pre logging, Pre pump test, Hydrofracturing & post pump test.

PRE LOGGING: The record of any characteristic information of the sub surface formations with depth of bore hole is known as well logging. Well logging, a sub surface geophysical technique, is carried out for an in situ evaluation of the aquifer's characteristics through measured physical properties. If the geoelectrical properties like Self potential, resistance and resistivity are studied by well logging, then it is called Electrical well logging. Electrical well logging is generally conducted by the Portable spot logger [Fig- 7]. The modes used to delineate the fractured zones are resistivity logs, either short normal or long normal logs and possibly fluid resistivity log. The low resistivity anomaly zones are indicative of good fractures. The normal resistivity log curves [Fig-8] may be correlated with the litholog of the bore well for better identification of aquifer zones.

PRE PUMP TEST; Pumping test is the most accurate reliable method to evaluate the hydraulic parameters of an aquifer, efficiency of well and safe operational rates of pumping. The objective of the Pumping test is to determine the aquifer parameters such as Transmissivity [T], Storage co-efficient [S], hydraulic conductivity [K], well performance and safe yield. Pre pump test is carried out to ascertain the yield of the bore well before hydrofracturing. Normally pump test is carried out for short durations. Generally to determine the effect from hydrofraturing, simple draw down test is conducted in the bore well and this can be combined with stepwise pump test. Generally the Specific capacity of the well is obtained by PT. Specific capacity of a well is its discharge per unit draw down expressed in LPM/ m draw down.

HYDROFRACTURING: Hydrofracturing is carried out depending upon the fracture systems. Normally up to three zones in each well are done. The operation must be commenced from bottom most fracture zones. Hydrofracturing will be fruitful and effective only if the process is done in the fractured zones below the water table.

POST PUMP TEST: The efficiency after fracturing is determined and compared with efficiency before fracturing. From the pump test data the well yielding capacity

can be obtained and compared before and after hydrofraturing. The hydrologic parameters like specific capacity, transmissivity and safe yield are commonly considered to determine the effectiveness of hydrofraturing. The ratio of yield of the bore well after hydrofrac to the yield before fracturing is defined as the Improvement Ratio.[IR].

Fig- 4, Bore Hole video camera.

Fig- 5, Packer Installation.

BORE HOLE VIDEO CAMERA: The fracture systems in the bore well are delineated by electrical well logging techniques by TWAD BOARD which has been doing s enormous works on this HF technique. But in the recent past CCTV [closed circuit television] camera technique is used to scan the sub surface through the bore holes. Tiny bore well video camera are sent inside the bore hole to scan the entire bore hole and the joint and fractures can be exactly located [Fig-4 & 6]. Frac Tech

[P] Ltd, Bangalore has done commendable video scanning of bore holes to ascertain the feasibility of well, whether it is feasible to go in for HF or not. Through the monitor the horizontal, vertical fractures, cavities and springs can be seen. Only after a careful feasibility study, the bore wells are selected for HF. For the better feasibility study, the electric well logging results can be correlated with the bore hole video image.

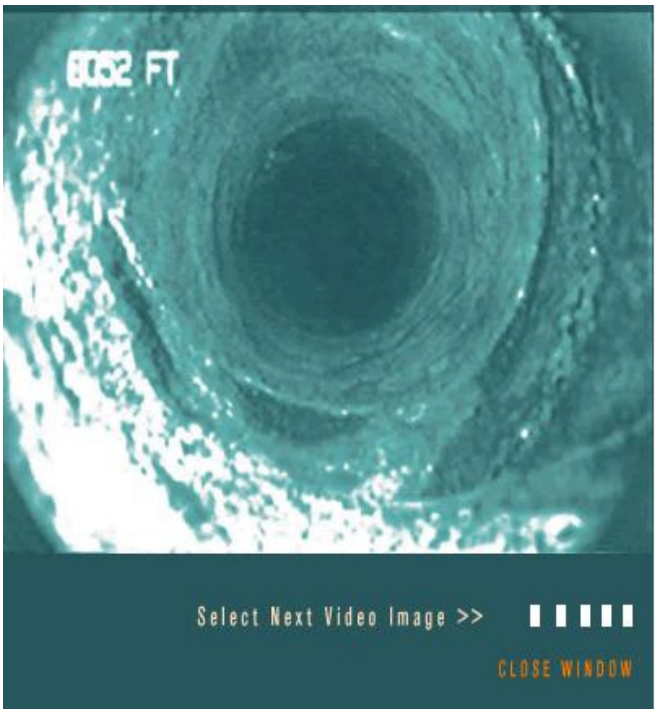

Fig- 6, Bore Hole Video Image.

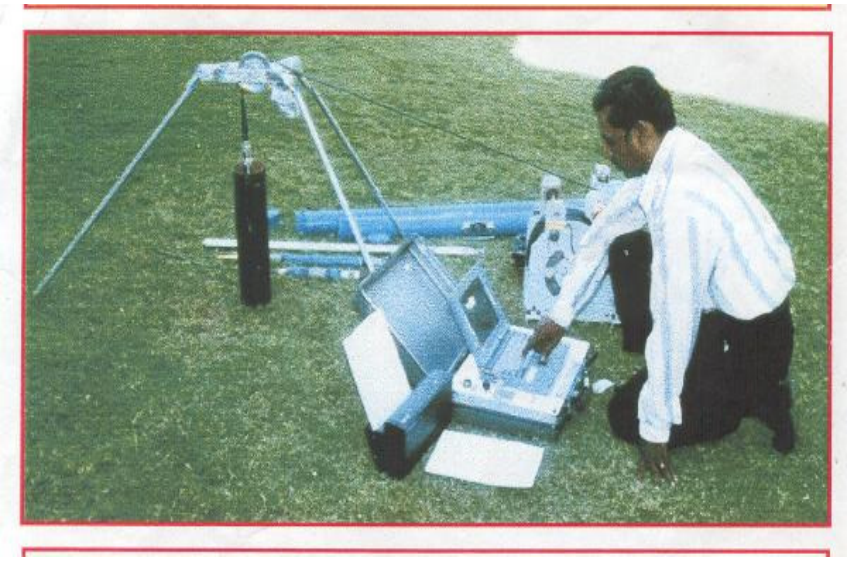

Fig- 7, Portable Spot Logger- Courtesy IGIS, Hyderabad.

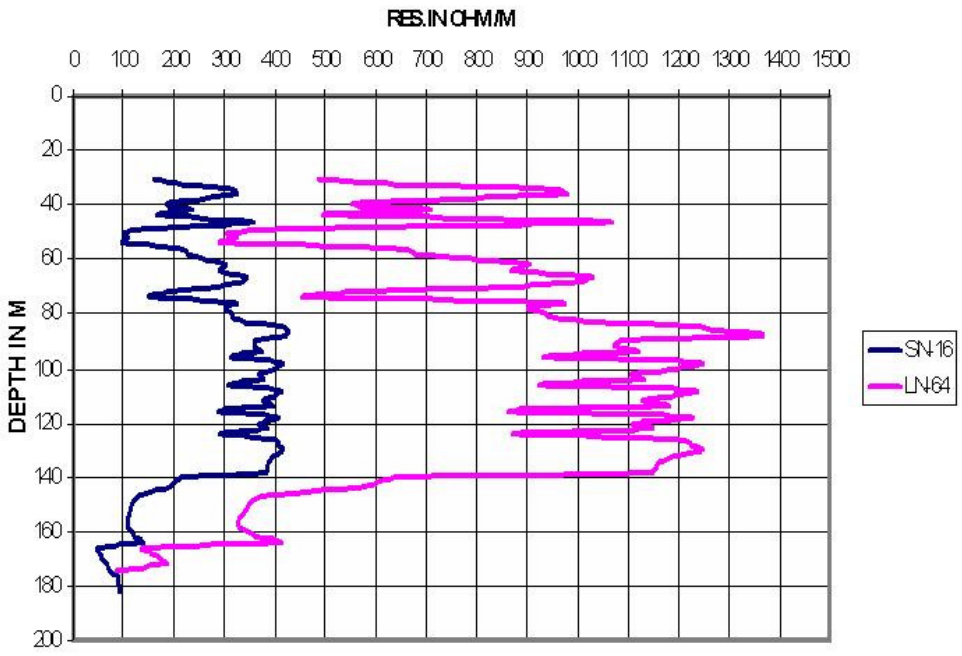

Fig- 8, Normal Resistivity Log Curves of hard rock bore having good fractures.

SUCCESS RATE : In Tamilnadu TWAD BOARD has been doing this HF techniques since 1989 and lots of failed wells are put into use for village water supply schemes.DANJDA under Water Supply and Sanitation Project, has conducted HF in 198 bore wells in Marakkanam union of Villupuram district. The ground water departments of the states of Rajasthan, Gujarat, Maharastra are actively engaged in this technique. In India about 30 hydrofracturing units are in operation. Frac Tech [P] ltd, Bangalore conducts this HF technique in Bangalore and in Karnataka state to rejuvenate the bore wells with encouraging success rate. Multi national companies like, Browning Hydrofracturing Inc, Precision well and Pump system Inc, Drill well Enterprises Ltd, Canada, USA and North West hydrofraturing Inc have been doing this HF services to revitalize the failed wells and poor yielding wells.

Documented Hydrofracturing results (by Northwest Hydrofracturing, Inc.)

Yield before hydrofracturing	Yield after Hydrofracturing	Increase in percentage
10 Gals/ day	1 Gals/ min	14,300
15 Gals/ day	1 Gals/ min	9500
0.5 Gals/ min	2 Gals/ min	300
2.0 Gals/ min	5.0 Gals/ min	150
2.5 Gals/ min	5.5 Gals/ min	120
4.0 Gals/ min	10.5 Gals/ min	162

Normally 65 to 70 % of average success is met with by this technique.

PERFORMANCE LIMITATIONS:

1. The water quality has got to be of a good standard which makes the effect worth improving the yield.
2. The rock must be of a jointed nature and in a condition which makes HF possible.
3. It must be recommended not to do in zones where the packer will be on rocks with a resistivity less than 50 Ω m. this is due to the risk of the packer getting struck.
4. The well must not have inclination, because this increases the risk of the packer unit to get struck in the well.

CONCLUSION: No doubt hydrofracturing technique is a good tool to revitalize, rejuvenate and rehabilitate the failed and unyielding bore wells in hard rock terrains. It is eco friendly and a boon as it saves time and money in drilling

T.S.BADRINARAYANAN,
GEOSCIENTIST, B SQUARE GEO TECH SERVICES,
KOLLIDAM, SIRKALI TALUK, TAMILNADU.
MOB- 94430 46102, E-MAIL- tsbadri56@gmail.com