QUANTIFYING WELL REDEVELOPMENT EFFORTS*

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ABSTRACT

A well redevelopment program has been quantified during redevelopment efforts on a water-supply well at a refinery in Puerto Rico. Initially, the program involved establishing pre-redevelopment baseline conditions utilizing a step-drawdown pumping test. The well was then redeveloped using a double-surge block in combination with an air-lift pumping system. A post-redevelopment step-drawdown pumping test was conducted to quantify the degree of improvement in the specific capacity and yield of the well. Finally, a 24-hour constant rate pumping test was conducted to establish the safe sustained pumping rate for the well and to compare the results to the original specific capacity determined just after well installation. The specific capacity and associated well yield were almost completely restored after a decline of over 50 percent.

INTRODUCTION

The maintenance of production wells utilized for municipal and industrial supply is often ignored and when approached, efforts are often poorly focused and rarely quantified. This field note provides a case study of a well redevelopment program for a production well that is used for process water supply at a refinery in Puerto Rico.

PRODUCTION WELL PW-3 OPERATIONAL DETAILS

In 1970, several production wells were installed for process water supply at a refinery in Puerto Rico. Production Well PW-3 was completed in unconsolidated deposits to a depth of approximately 150 feet (45.7 meters) below ground surface (bgs). The unconsolidated deposits are comprised of sand, silt, and clay. Figure 1 provides a construction diagram for PW-3.

After the installation of PW-3, a 24-hour constant-rate pumping test was conducted at a rate of 556 gallons per minute (gpm) or 2100 liters per minute (lpm). The specific capacity of this well, after 24 hours of pumping, was 9.6 gallons per minute per foot of drawdown (gpm/ft) or 119 liters per minute per meter of drawdown (lpm/m). Based on an analysis of the pumping test data, it was determined that Well PW-3 could be pumped at a sustained rate of 400 gpm (1510 lpm). By 1988 PW-3's yield was reduced to the point that its production rate and specific capacity had declined by over 50 percent.

REDEVELOPMENT PROGRAM

In July, 1989 a redevelopment program was initiated on PW-3 which involved the following major steps:

- The conductance of a pre-redevelopment step-drawdown pumping test to document operational conditions and specific capacities at different pumping rates.
- Well redevelopment using a double-surge block in combination with an air-lift pumping system.
- The conductance of a post-redevelopment step-drawdown pumping test at rates similar to the pre-redevelopment test to quantify the degree of improvement in specific capacity.
- The conductance of a post-redevelopment 24-hour constant rate pumping test to quantify the safe sustained pumping rate for the well.

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Pre-Redevelopment Step-Drawdown Pumping Test

Prior to the redevelopment of PW-3, a step-drawdown pumping test was conducted to quantify well operational conditions, specific capacity, and well efficiency. The test involved pumping the well at three different pumping rates for one hour at each rate. A summary of pre-redevelopment specific capacities is provided in Table 1 and Figure 2 provides a plot of water-level drawdown versus time for the various steps.

Well Redevelopment

PW-3 was redeveloped using a double-surge block assembly and an air-lift pumping system. A cable-tool drilling rig was used to move this assembly up and down inside the well screen at approximately 30 strokes per minute. The surge block was comprised of two disks fitted with rubber gaskets attached to a perforated pipe as shown on Figure 3. The rubber disks are generally custom made for each well redevelopment project so that they fit snugly inside the well screen for the surging motion.

The surging motion forces water to flow into and out of the well screen, dislodging fine grained sediment materials from the gravel pack and the formation immediately surrounding the well screen. Compressed air is used at the same time to create an air-lift pump that removes water and sediments from the well. In our experience, a cable-tool rig is the optimal machine to operate this assembly, as it can attain a high number of strokes per minute.

Surging action should be started at the top of the well screen to avoid sand locking the surge-block assembly. When the water discharge becomes free of sediment, the assembly is lowered to the next 5-foot (1.5 meter) section of screen; this procedure is followed until the entire well screen is developed. The double-surge block method is effective for wells with both short and long screen sections since it concentrates the development energy on short sections of the well screen and aquifer.

During the redevelopment program, the well's specific capacity was measured on a daily basis to evaluate improvements. Water and sediment from the discharge hose were also collected and examined to document redevelopment progress.

Total redevelopment time can range from a few hours for small diameter wells with short well screens to many days for large diameter wells with long screens. PW-3, which was constructed with a 35-foot (10.6 meter) screen, required approximately 5 days of redevelopment time.

Post-Redevelopment Pumping Tests

After the redevelopment program was completed on PW-3, a step-drawdown pumping test was performed to evaluate the effectiveness of the redevelopment program. The test involved pumping the well at the same pumping rates as for the pre-redevelopment test and at two higher rates. A comparison of the specific capacity data for the pre- and post-redevelopment step drawdown pumping tests is provided in Table 1. An analysis of these data indicates that the development program resulted in a doubling of the well's specific capacity. Figure 2 provides a plot of water-level drawdown versus time for both the pre- and post-redevelopment step-drawdown tests.

In addition, a 24-hour constant-rate pumping test was performed to evaluate aquifer hydraulic characteristics and estimate a safe, long-term pumping rate for the well. The specific capacity at the end of the 24-hour pumping test was 9.1 gpm/ft (113 lpm/m); this 24-hour specific capacity is comparable to the original specific capacity of 9.6 gpm/ft (119 lpm/m) in 1970.

CONCLUSIONS

- Well redevelopment using a double-surge block and air-lift pumping system has proven to be a very aggressive and effective method to restore well yields in wells completed in unconsolidated aquifers.
- The redevelopment program for PW-3 resulted in restoring the well close to its original yield and specific capacity.
- This method has also proven to be effective in rehabilitating open hole (non-screened) wells completed in consolidated bedrock aquifers.

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TABLE 1

SUMMARY OF SPECIFIC CAPACITIES FOR STEP-DRAWDOWN PUMPING TESTS PRODUCTION WELL PW-3.

PUMPING RATE (GPM)	Q/s** BEFORE REDEVELOPMENT DATE: 07-13-1989	Q/s** AFTER REDEVELOPMENT DATE 08-09-1989
200	5.0	—
250	4.8	11.9
300	4.6	11.1
350	—	10.7
400	—	10.3

Q/s** - SPECIFIC CAPACITY IN GALLONS PER MINUTE PER FOOT OF DRAWDOWN (GPM/FT)

GPM - GALLONS PER MINUTE

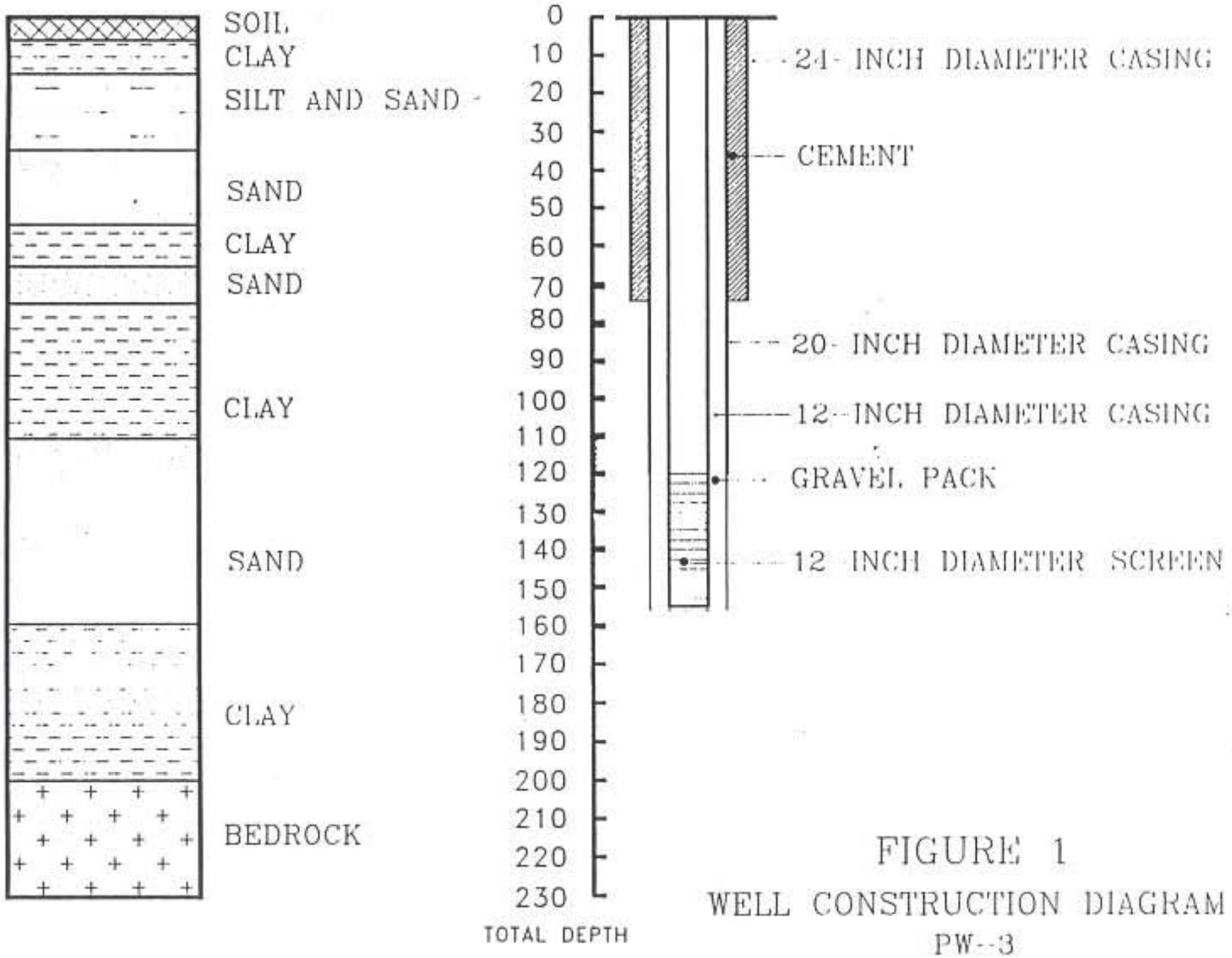


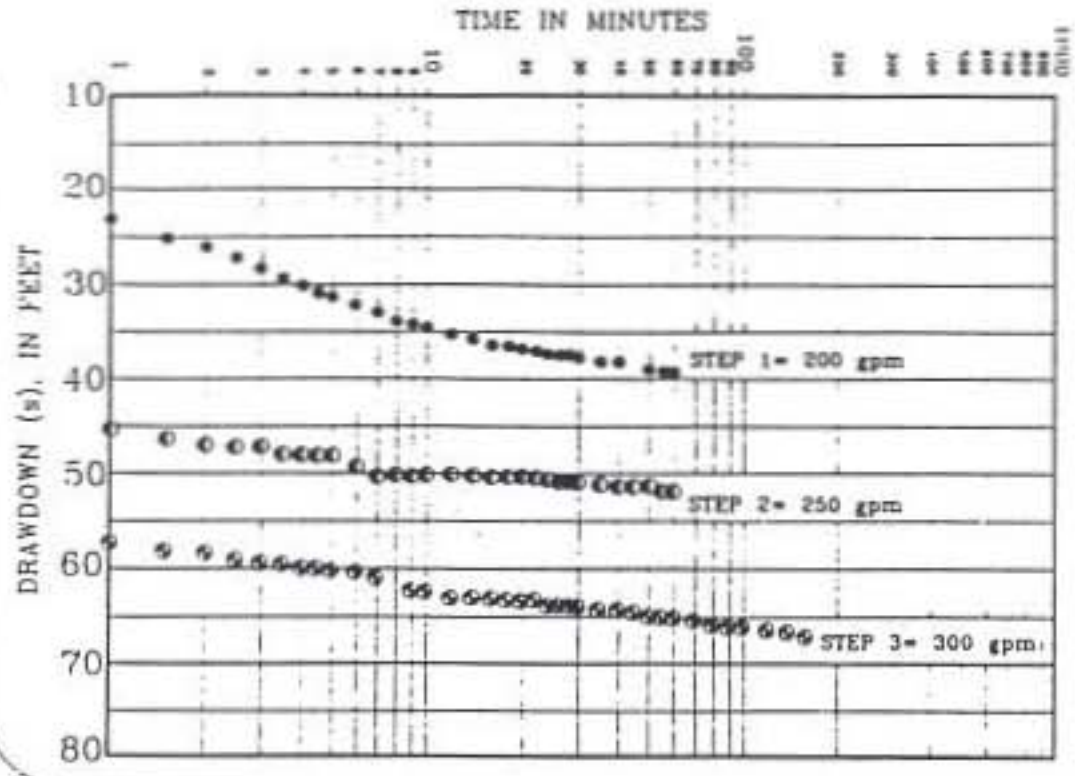
FIGURE 1

WELL CONSTRUCTION DIAGRAM

PW--3

PRE-DEVELOPMENT PUMPING TEST

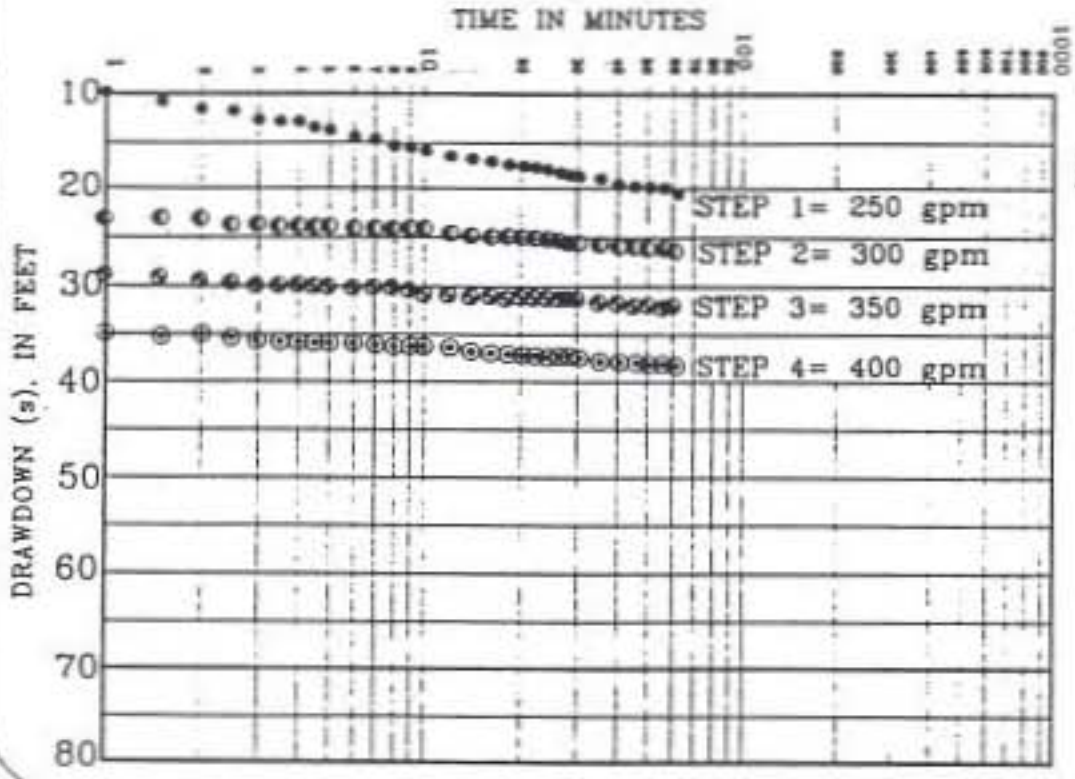
SEMI-LOGARITHMIC PLOT OF DRAWDOWN VERSUS TIME
FOR PRODUCTION WELL



STEP	GPM	Q/s
1	200	5.0
2	250	4.8
3	300	4.6

POST-DEVELOPMENT PUMPING TEST

SEMI-LOGARITHMIC PLOT OF DRAWDOWN VERSUS TIME
FOR PRODUCTION WELL



STEP	GPM	Q/s
1	250	11.9
2	300	11.1
3	350	10.7
4	400	10.3

FIGURE 2

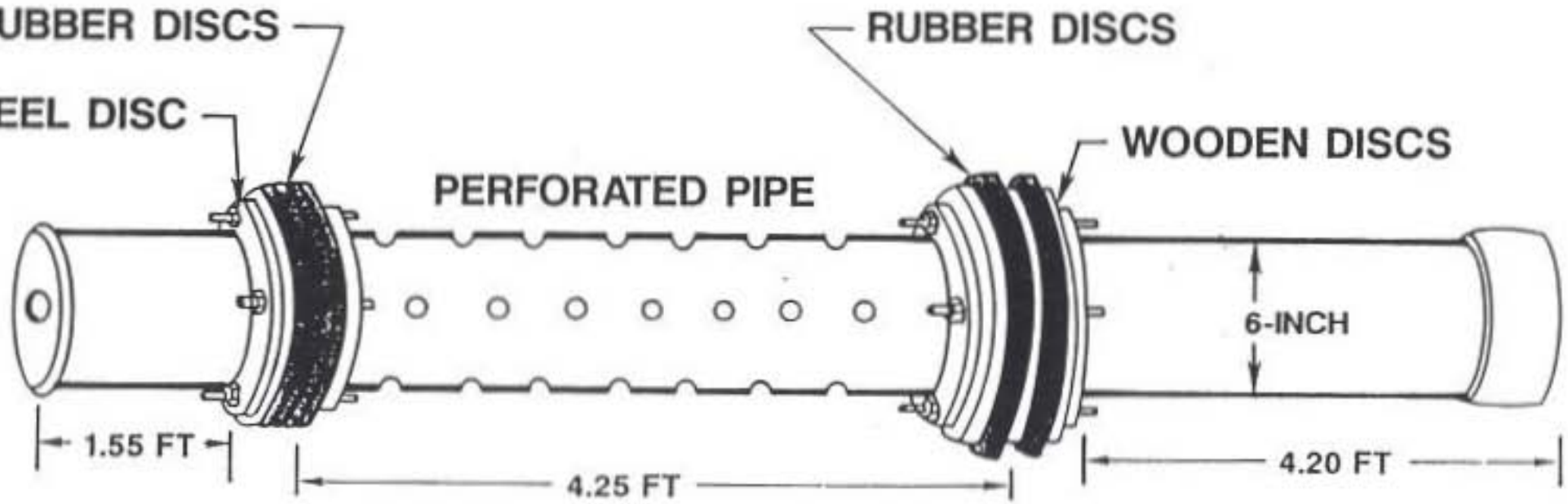


FIGURE 3. SCHEMATIC SURGE-BLOCK CONSTRUCTION DIAGRAM