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Tide-well Systems III:
Improved Interpretation of Tide-well Records

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ABSTRACT

Recent studies of the non-linear response of the conventional tide-well system have pointed out the deficiencies of the system when the tide records are to be used for scientific purposes requiring very accurate data. An experimental method of checking the response of such tide-wells, by means of a drainage test, is described. This provides the basis of a further method, by which the height of the water level in the well may be approximately corrected to give the height of the sea level outside the well. The application of these methods, to a recently advocated linear tide-well system, is also described.

1. INTRODUCTION. In a number of papers (e.g. Noye 1970, 1974a,b), the response of several types of tide-well systems has been examined in detail. For the conventional tide well, which has an orifice connecting the water in the well with the sea outside, it was shown that, for a narrow deep well, the governing differential equation has the form

\[ \frac{dH_w}{dt} + C_1 |H_w|^{1/2} \text{sgn}(H_w) = \frac{dh_0}{dt} \]

(1.1)

where \( t \) is the time and \( H_w(t) \) is the head response of the tide well to the fluctuations in sea level, \( h_0(t) \).

\[ H_w = h_0 - h_w \]

(1.2)

where \( h_w \) is the height of water in the well, referred to the same datum as the sea level. \( C_1 \) is a constant, depending only on the dimensions of the tide well, viz.,

\[ C_1 \approx C_e (2g)^{1/2} A_p / A_w \]

(1.3)

1. Received: 11 February 1974.
where \( A_w \) is the uniform area of cross-section of the well, \( A_p \) is the area of
the orifice, \( g \) is the acceleration due to gravity and \( C_c \) is the contraction coef-
cient of the orifice, generally taken to be \( C_c \approx 0.6 \).

For the tide well with a long horizontal pipe connection near the sea floor, it
was shown that, provided a parameter \( N \geq 5 \), the head response to the fluctu-
ating sea level is given by the following relation, derived assuming steady
Poiseuille pipe flow,

\[
dH_w/dt + C_2 H_w = dh_0/dt, \tag{1.4}
\]

where the tide-well constant, \( C_2 \), is given by

\[
C_2 = gD_p^4/32vL_pD_w^2. \tag{1.5}
\]

Here \( v \) is the kinematic coefficient of viscosity of sea water, \( L_p \) is the length
and \( D_p \) the uniform diameter of the pipe connection, \( D_w \) is the uniform dia-
meter of the circular well and

\[
N = \frac{128v^2L_pD_w^2}{gD_p^6}.
\]

The response of the non-linear system described by equation (1.1) is depend-
ent on the parameter \( C_1 \) (Noye, 1974a); the response of the linear system de-
scribed by equation (1.4) depends on \( C_2 \) while, for \( N < 5 \), unsteady effects in
the upper pipe flow produce a more complicated form for the response (Noye,
1974b).

In many tide-well installations, the value of the tide-well constant (\( C_1 \) or
\( C_2 \)) is not well known. For instance, the orifice of a conventional tide well
might not be sharp edged or exactly circular, so that the contraction coefficient
\( C_c \) might be unknown, or marine growth might have reduced its area after
installation. Methods of determination of the tide-well constants and the re-
sponse function from drainage tests, in the field or the laboratory, can over-
come this problem.

For the conventional tide well, an experimental method for finding \( C_1 \) and
hence the pseudo-response of the system is described in the next Section. For
a linear system with \( N \geq 5 \), the quasi-steady theory is a good approximation and
the method described in Section 2 may be used. For \( N < 5 \), a more general
method is applicable. In addition, two cases which can occur if the well is
tested in situ, when the water level outside the well does not remain constant
during the tests, are described.

The response of conventional tide wells seems well established for two reg-
imes of sea-level oscillations; there is negligible response to wind waves (apart
from “set-down”) and unit response with no lag to oscillations of tidal period.
For oscillations such as tsunamis and harbour seiches, which have periods
between these two regimes, the response varies according to the dimensions of