REPORT ON LOW FLOW FORECASTING
FOR BERRY SPRINGS

SUBMISSION

This report prepared by A. Hamrozi of the Hydrographic Section of the Mines and Water Resources Branch under the general direction of Senior Engineer Hydrographic, is submitted for your information.

DIRECTOR OF MINES AND WATER RESOURCES

D. KINGSTON
Senior Engineer
Hydrographic Section
ABSTRACT

The purpose of this report is to ascertain whether the groundwater discharge of certain springs can be predicted, using rainfall precipitation as an index independent of other influencing factors.

This is based upon the relationship of Antecedent Precipitation Indices (API) and groundwater discharge recession characteristics.

Using these values, predicted discharges are read off the API - mean discharge graph. If further rain falls in the area, the API can be amended by adding the new rainfall to the original value and multiplying this by the decay factor.

It is acknowledged that a more detailed study of the aquifer, recharge area, soil moisture balance etc., is possible.

This forecasting system is presented here, however, as satisfactory forecasts have been achieved as can be seen on figures 6 and 7.
THE METHOD

Primarily, it was essential to establish the yearly discharge - rainfall cycle and to ascertain any relationship between a given rainfall station and the spring discharge.

Using available gauging and gauge height readings, yearly groundwater discharge hydrographs were constructed. Against these were plotted the cumulative rainfall graph for Manton Dam, those having the best correlation characteristics of the available rainfall stations. As groundwater is a form of lagged rainfall, and the hydrologist's concept of an antecedent precipitation index (API) is also a form of lagged rainfall, a relationship between flow and API values was sought.

To establish this relationship, the behaviour of the spring groundwater (i.e., its recession constant) was examined to select a decay factor with which to generate an API series.

From the constructed groundwater hydrographs, monthly mean discharges in acre feet were computed (fig. 2 table I) and these values used in obtaining the recession constant of the springs, using the formula:

\[ \frac{Q_n}{Q_{n-1}} = \beta \]

Where \( Q_n \) = discharge for month "n"

and \( \beta \) = the recession constant for month "n"

(see fig. 2 table 2).

A graphical plot of these values (fig. 4) shows a reasonable consistency during the critical dry season period, with a more pronounced scatter in the early wet. This is no doubt due to the fact that rainfall falling in the early month of the wet does not affect the groundflow until approximately 15" is recorded. Thus, while the values of API increase, the groundflow remains at a steady recession. The mean value of \( \beta \) was computed using the months of June, July and August, and a figure of 0.77 obtained.

This mean value was adopted for the API decay factor as shown later.

From the monthly rainfall figures for Manton Dam, a table of monthly API values were computed from the formula:

\[ \Delta t_n = (\text{API}_{n-1} + \text{MP}_{n-1}) \times \beta \text{ mean.} \]

where \( \Delta t_n \) = monthly API value for month "n".

\( \text{MP}_{n-1} \) = monthly rainfall in points for preceding month, starting with API = 800 for September 1957.

and \( \beta \text{ mean} \) = mean value of recession constant for month of June, July, August (from table II).

This allowed 48 values to be computed in which the values have been correlated. The effect of the initial assumption of 800 is eliminated by calculating the series for several years before the period in which the correlation has been attempted.
These A.P.I. values were plotted against those of the actual discharge available, and a curve of best fit drawn. (Fig. 5)

Some of the A.P.I. - discharge relationship values, especially for the wet season month, plotted well above the mean curve. It is known that these values contained surface runoff as well as ground flow. However, since the forecast is concerned with dry season flow, these are discounted. Thus A.P.I. values can be generated for any given month, for which rainfall records are available, and the equivalent discharge read off the graph.

To test the accuracy of the predicted data, discharges were generated for the 5 years for which actual discharges are available. These were plotted as yearly hydrographs (Fig. 6). For the first 3 years, predicted discharges vary with the rising stage and maximum flow from the actual values. Minimum values, although displaced considerably in time, are accurate and so is the recession. For 65-66 and 66-67 years, the predicted discharges have somewhat improved in the critical month of the dry season and it is hoped that this trend will continue.
CONCLUSION

It is evident from Fig. 1 that approximately 15" of rain is needed before there is any change in the ground flow from a steady recession to that of increased discharge. While this rainfall contributes to the values of A.P.I. and thus the apparent increase in discharge, in actual fact its only contribution is in the recharge of the soil moisture. By eliminating this anomaly, it may be possible to adjust the time factor of minimum flows and the predicted rise to that of the actual rise.

Modifying the formula for A.P.I. as follows may achieve this:

\[ \text{A.P.I.}_n = |\text{A.P.I.}_{n-1} + (\text{MP}_{n-1} - B)| \times \frac{1}{\mu} \]

using only positive values of \((\text{MP}_{n-1} - B)\)

A further refinement envisaged is in the precise geographical location of the recharge catchment to the location of the rainfall station.

A study of intensity-duration, runoff patterns, and the possible separation of that rainfall which would be accounted for by surface runoff and evaporation. More representative values of infiltration rain may result. Thus, revised rainfall values would be used to compute the A.P.I. values on which those predicted discharges are based. It is considered that this would 'flatten' the lower part of the predicted recession and bring it closer to the actual value.
### Table I
**Mean Discharge in Cubic Feet**

<table>
<thead>
<tr>
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<td>4.52</td>
<td>3.45</td>
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<td>14.5</td>
<td>11.0</td>
<td>8.58</td>
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### Table II
**Recession Constant**

\[ \beta = \frac{Q_n}{Q_{n-1}} \]

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<td>—</td>
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<td>0.70</td>
<td>0.70</td>
<td>0.79</td>
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<tr>
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<td>0.93</td>
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<td>—</td>
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<td>0.85</td>
<td>0.74</td>
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Mean value for June, July, August = 0.77
### TABLE III

MONTHLY API (MINTON DAM)

\[ API_n = \left( \frac{API_{n-1} + MP_{n-1}}{\beta} \right) \times \text{mean} \]

where \( API_n \) = monthly API value in month 'n'

\( MP_{n-1} \) = monthly rainfall in points for preceding month (starting with API = 800 for Sept. 1957).

\( \beta \) = Mean coefficient (June, July, August).

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<tr>
<th>MONTH</th>
<th>SEP</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
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<th>JUNE</th>
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<td>3550</td>
<td>2760</td>
<td>3170</td>
<td>2440</td>
<td>1890</td>
</tr>
</tbody>
</table>
BERRY SPRINGS AREA
SHOWING ROCK OUTCROPS & TENTATIVE GEOLOGICAL INTERPRETATION.

LEGEND

(FILE) - Formation

(QC) - Quartz breccia, siltstone, limestone, quartz breccia, often altered by silicified breccia

(D) - Dip of bedding in shale, siltstone, limestone

(W) - Waterhole

(S) - Seasonal spring

(R) - River

(M) - Main road

(1) - Track

INTERPRETED GEOLOGICAL FEATURES:

- Faults

- Northern boundary of quartz sandsstone outcrops

very few outcrops in this area.