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INTERNAL REPORT

DILUTION GAUGING IN S. GEORGIA

1972 and 1973

SUBSURFACE SECTION REPORT

No. 57

C J SMITH
Oct 1973

NATURAL ENVIRONMENT RESEARCH COUNCIL

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DILUTION GAUGING - S. GEORGIA 1972 AND 1973

The measurement of flow by dilution gauging has been used to check the stage-discharge calibration of a flume in S.Georgia. A series of gaugings in 1972 followed by a further series in 1973 resulted in stage-discharge relationships which deviated from the theoretical because of the effects of storage on the dilution gauging samples. Correction of the flow measurements for sample storage effects has been considered, but is not possible. The use of another salt Sodium Iodide, and glass bottles for samples, should result in a calibration for the flume from gaugings carried out in 1974.

1972 GAUGINGS

The results of gaugings carried out during the early part of 1972 showed large discrepancies from the theoretical stage-discharge relationship of the flume. There was no significant relationship between the points on the stage-discharge curve determined by dilution gauging (see Fig. 1).

Nevertheless, at the time that the results of the gaugings were determined, it was felt that a curve drawn through the points determined by dilution gauging was probably a better estimate of the stage-discharge relationship for the flume than the theoretical one. Since then it has been found that the discharges measured could be, and most probably are, in error by significant amounts, due to the loss of tracer from solution during the time between the collection of the samples and their analyses - a period of approximately 3 months.

There were some significant points concerning the chemical analyses of these 1972 gaugings which obscured the sample storage problems.

1. The standard solutions containing sodium dichromate, (75 µg/l Cr^{6+}) which were designed to check on the deterioration of the samples when stored for long periods, had mostly remained unchanged, although one set had changed and contained lower chromium concentrations.

2. The samples of "background" water, ie water from the stream taken above the point at which tracer was injected and therefore supposedly containing no tracer, showed large variations in their concentrations of chromium.

3. There were large variations in the concentrations of chromium in the samples taken from the flume.

4. The samples of the injected solution taken from the Mariotte bottle befo and after injection showed good agreement.

It was concluded from the above observations that:

a) The samples were not subject to loss of chromium during storage, and that the one devious set of standards could have been due to a wrongly prepar standard solution. The remainder of the standards showed very good agreement with the standard solution prepared at the time of analysis from a solution containing 75 μg/ml Cr^{6+} (part of the same solution was sent to S. Georgia from which their standard solutions are prepared).

b) There had been contamination of the background samples.

c) If (b) was the case, the variation in the concentration of chromium in the stream samples could also have been due to contamination.

d) The Mariotte bottle contents had been well mixed(and the Mariotte bottle discharge data showed that a constant input of tracer was being made.). Thus variation in the amount of tracer being added to the flow could be discounted as a source of the variation in stream sample concentration. The variation in concentration of the stream samples could also be explained if complete mixing of the injection tracer had not occurred before the sampling point.

As a result, further instructions for the gauging work to be carried out in 1973 were given:

Greater care should be taken to avoid the possibility of contaminating samples, and that the samples from the Mariotte bottle should be dispatched separately.

The samples of background water should always be taken upstream of the Mariotte bottle.

The site for injection should be moved further upstream to provide a longer gauging reach for mixing.

It was expected that a good calibration of the flume, and the v-notch being installed, would result from such work.

1973 GAUGINGS

Between the time of the dispatch from S. Georgia of the 1973 dilution gauging samples and their arrival at I.H., it had been found that the storage of dilution gauging samples containing chromium, in plastic bottles, was proving to be unsatisfactory over long periods. As a result, long term storage experiments were being carried out.

Our investigations were showing that solutions of chromium in many types of plastic bottles lost chromium within a short period (some types of bottle showed a loss within 1 day) and that samples in the same type of bottle deteriorated at different rates. This suggested that it would not be possible to apply corrections factors to samples for the loss of chromium with time.

Thus the standard solutions prepared in S. Georgia to contain 75 µg/l Cr^{6+} were analysed first to determine whether storage had affected the samples. As expected, they were found to contain varying amount of chromium and none contained the standard amount. The maximum concentration of chromium found in a standard was 69 µg/l. Analysis of gauging samples and the subsequent calculation of discharges seemed to be of little practical value, but it was decided that the samples from 6 gaugings would be analysed. The gaugings were selected to give the best cover of the stages at which gaugings had been carried out during 1973. The results of these analyses and the calculated discharges would be subject to errors, but it would be of interest to compare the deviation of the resulting stage-discharge relationship from the theoretical, with that from the 1972 results, and if possible to confirm that both years gaugings had failed because of sample storage problems and not for other reasons.

The samples showed similar variations to the 1972 samples, apart from the 75 µg/l Cr^{6+} standard solutions.

a) The standards showed much more variation in concentration than their 1972 counterparts and none of them contained as much as 75 µg/l Cr^{6+}. In addition, the standards were conspicuous in the way that they affected the analytical system, and it appeared that these standards may have been prepared in a different supply of water to that which flows in the stream, from which the remainder of the samples were obtained.

(b) The samples of "background" water again showed variations in their chromium concentrations, and the stream samples (from the flume) showed wide variations in chromium concentration.

(c) The samples from the Mariotte bottle showed good agreement.

It was concluded that the 1973 samples repeated the pattern of the samples from the previous year, except for the standards, which had behaved in the way expected of their storage medium. The 1972 standards had been the factor that had given that year's results credibility.

The stream samples contained widely varying concentrations of tracer despite the increased mixing length, suggesting that the 1972 mixing length had been adequate.

The whole pattern of variation in sample concentrations was now known to be due to the storage of the samples before analysis.

COMBINED RESULTS OF THE 1972-1973 GAUGINGS

The plotted stage-discharge results from the gaugings (see Fig I and Fig II) show similar deviations from the theoretical curve - the discharges measured by dilution gauging being apparently larger than their theoretical equivalents. It is now understood that the loss of tracer from the stream samples during storage indicated apparently larger dilutions of the injected tracer than had in reality taken place, and higher calculated discharges were the result.

The samples of background water from both years' gaugings contained varying amounts of chromium. After the 1972 results, it was considered that the most likely cause of this was contamination, and greater precautions against this possibility were requested for the 1973 gaugings. Following similar results for the 1973 background samples it is possible that the variation in chromium concentration is real. Alternatively, there may be a constant background concentration of chromium, samples of which were subject to the same loss from solution during storage as the other samples and standards.

The standards (containing 75 μg/l Cr^{6+}) showed no loss of tracer in 1972 (apart from the one set of standards which was assumed to have been wrongly prepared), and showed large losses in 1973. There is no satisfactory explanation for the non-typical behaviour of the 1972 standards. It is possible that the 15 bottles involved were part of a batch which had slightly different chemical characteristics to most of the other bottles sent to S. Georgia. During the experiments into sample storage at I.H., it was found that some plastic bottles from a batch behaved in the same way as the 15 bottles mentioned above, while the remainder were subject to losses of chromium. However this did not apply to all types of bottle. All the bottles from the majority of the various types lost chromium, although the rates at which lossess occurred varied considerably from bottle to bottle.

Proposals for future work

As a result of storage experiments, glass bottles (50 ml capacity) have been sent to S. Georgia for the collection of all dilution gauging samples. In addition, Sodium Iodide (1 Kg) has been sent to S. Georgia as an alternative dilution gauging chemical tracer. This salt has been chosen as an alternative to Sodium Dichromate because it also has the properties which make it suitable for dilution gauging,eg its occurrence in rivers etc. is at very low concentrations and this "background" concentration does not, in our experience, vary to any large extent. It has the advantage over Sodium Dichromate that it is non-poisonous. Sodium Iodide was not available for use as a dilution gauging tracer at the time that the S.Georgia programme was planned, because insufficient experience had been gained in its use.

Storage experiments with Sodium Iodide have shown that its solutions are stable in glass bottles for many weeks.

A standard solution of Sodium Iodide has been prepared at I.H., part of which has been sent to S. Georgia for preparation of standards. Large plastic bottles (1 litre capacity) have been sent for the collection of background water, necessary for the analytical procedure when determining Iodide.

A concentrated solution of Sodium Iodide for dilution gauging should be prepared as follows:-

> Dissolve 500 grammes of Sodium Iodide in water (approx 1500 ml) and make the solution up to 2 litres with water. This solution contains 250 grammes Sodium Iodide per litre and 211 grammes Iodide (I^-) per litre. The solution is used for dilution gauging in precisely the same way as the

solution of Sodium Dichromate containing 209 grammes per litre of chromium (Cr^{6+}). When using Sodium Iodide, extreme care must be taken not to contaminate samples etc. as the solution is colourless, and therefore the possibility of contamination is that much greater than with a coloured tracer. Sodium Iodide is however not a toxic material, - there is no danger of poisoning.

It is proposed that gaugings should be carried out using both Sodium Iodide and Sodium Dichromate. Eight gaugings using Sodium Iodide covering the range of stage required for the stage-discharge relationship, and a further eight gaugings using Sodium Dichromate over the same range of stage, - where possible duplicating the stages used for the sodium iodide gaugings.

The gaugings should all be carried out in the same manner as previous years' sodium dichromate gaugings, apart from the collection of a large bottle of "background" water above the injection point during each gauging. The normal background samples must still be collected. If the standards have previously been prepared in the supply of drinking water at base or any other water supply different to that in the stream (above the injection site), then in future they must be prepared in water from the stream flowing through the flume.

It is expected that the 1974 gaugings will produce;

1. Standard solutions containing 75 μg/l Cr^{6+} or 52 μg/l I^- at the time of analysis.
2. Stream samples containing consistent amounts of tracer during each gauging (approx 50 μg/l Cr^{6+} or I^-).
3. Background samples containing constant concentrations of Cr^{6+} and I^- (hopefully 0. μg/l).

and that this will lead to the production of a useful stage-discharge calibration for the flume and the V-notch.

CJS/VW
23.10.73

S. GEORGIA FLUME STAGE v. DISCHARGE 1972

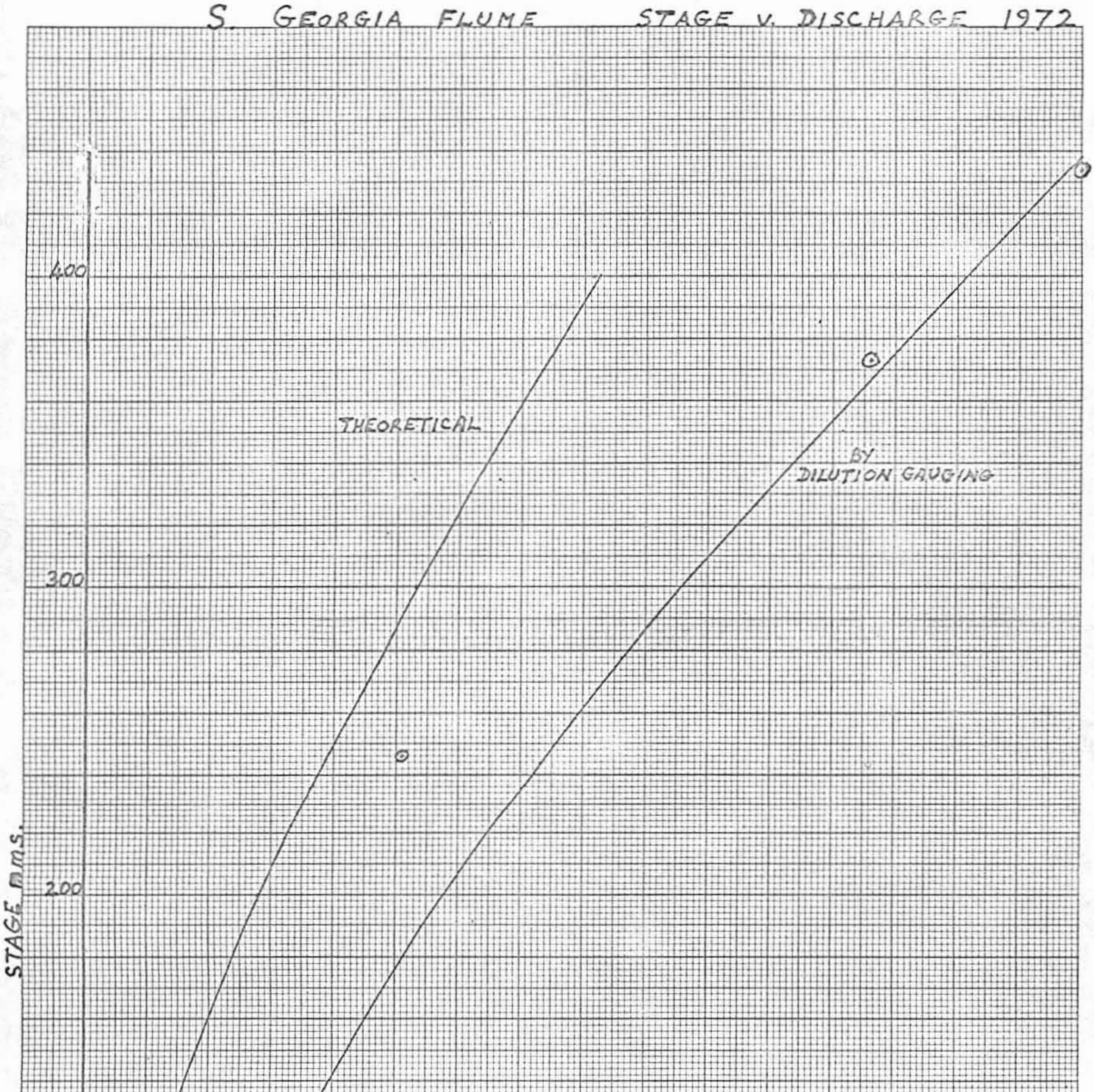

FIG. 1

S. GEORGIA FLUME   STAGE v. DISCHARGE 1973

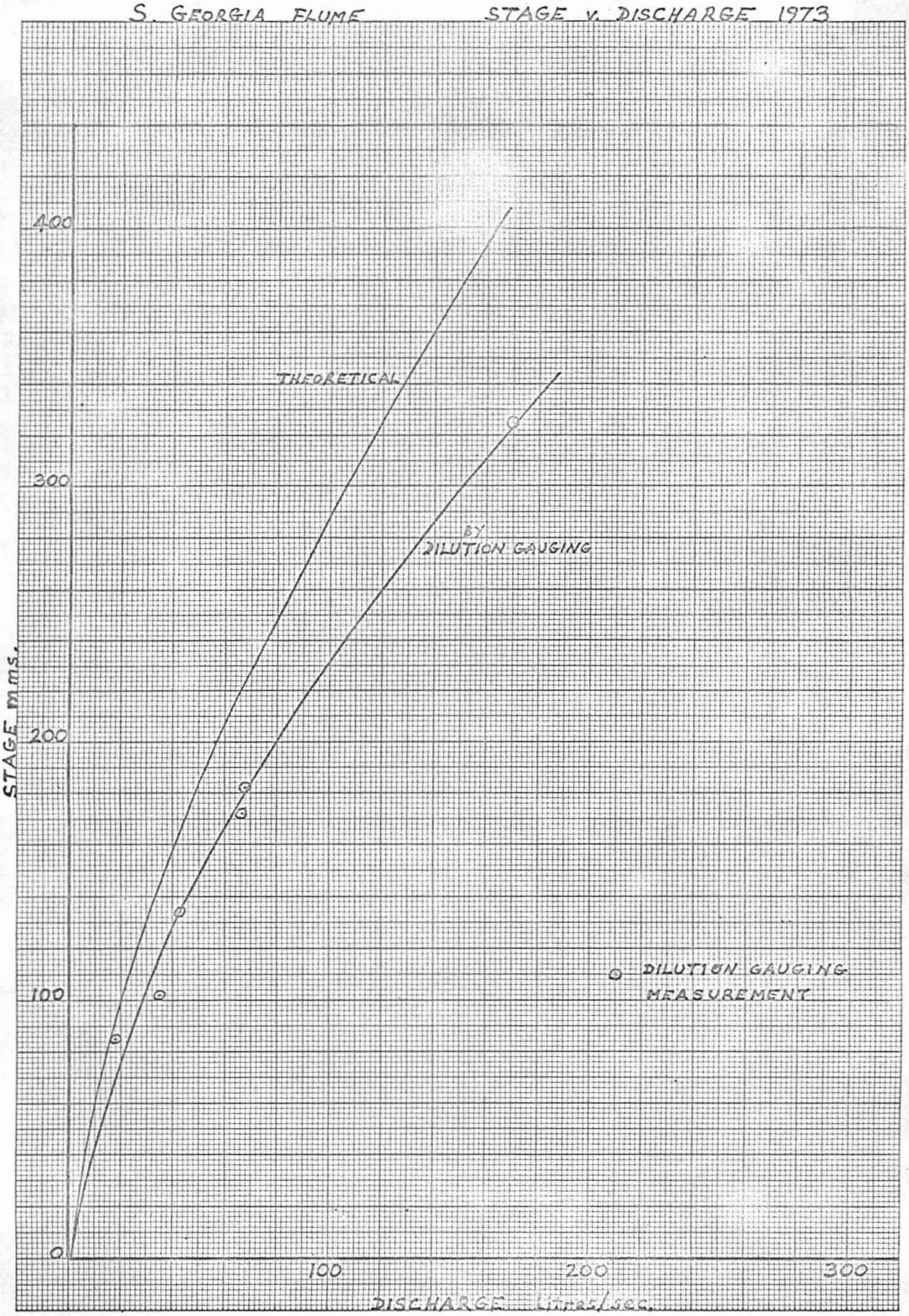

FIG 2.