Effects of Reservoir Water Levels on the Sydney Gravity Calibration Range

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Iasky and Iasky (1977) recently drew attention to the effects of changing water levels in the Mundaring Weir on the Perth gravity calibration range. Their conclusion was that while varying water levels are manifested as a change in observed gravity over the range, that change is very small and is beyond the sensitivity of modern gravity meters.

The Perth range is not the only calibration range in Australia which is affected by changes in water levels in nearby storage structures. The Sydney range consists of stations at Lane Cove and Wahroonga (Barlow, 1967) with the elevation difference between the stations being the dominant contributor to the observed gravity differential. There are two stations at Wahroonga – station 6091.0305 is located within 1m of one wall of the 45 X 10^6 ℓ Neringah Avenue water reservoir, with an alternative station 6091.0205 located in nearby Illoura Avenue. The location of the Neringah Avenue station is shown in figure 1.

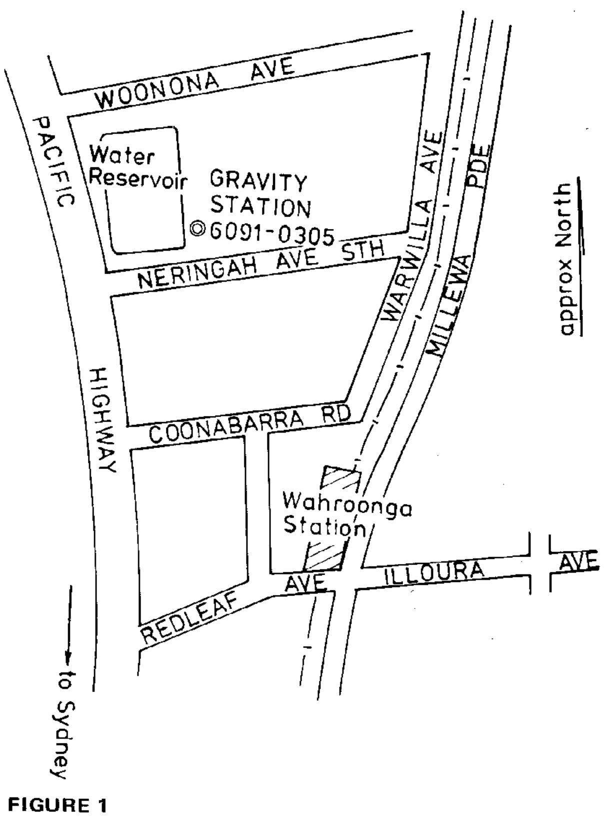

FIGURE 1
Location of Wahroonga gravity station.

The Neringah Avenue reservoir approximates a right rectangular prism in geometry. Its dimensions have been supplied by the Sydney Metropolitan Water Sewerage and Drainage Board, and using these, the gravity anomaly at station 6091.0305 for varying water levels has been computed using the formulas published by Nagy (1966). The curve for water depths varying from zero to full capacity of 10m are shown in figure 2.

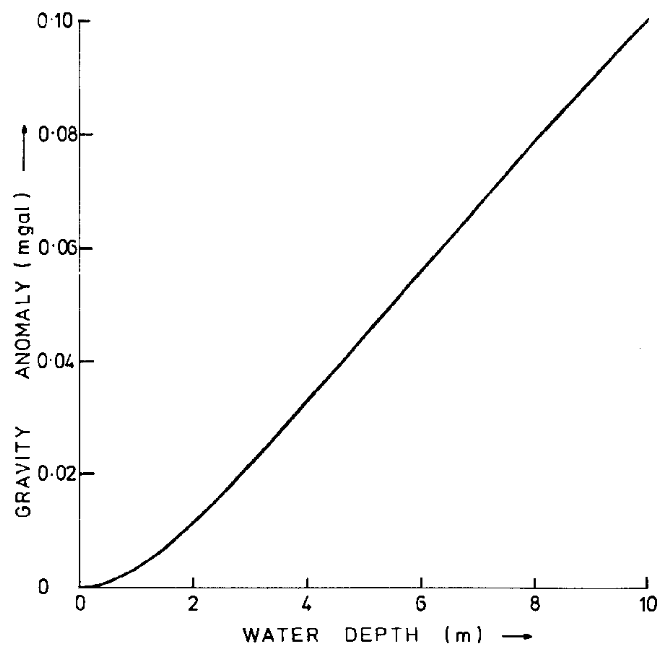

FIGURE 2
Gravity anomaly at calibration station as a function of water depth in Neringah Avenue reservoir

Barlow (1967) has established that the gravity difference between the Lane Cove and the Neringah Avenue stations is 61.99 mgal. Figure 2 shows that a water level change in the Neringah Avenue reservoir of 2m produces an anomaly of 0.01 mgal, approximately the limiting sensitivity of most gravity meters. The maximum anomaly between a completely discharged and completely full reservoir is about 0.10 mgal. The water level never falls below the station elevation, and so the effect of the water mass is to reduce the observed gravity at the calibration station. Water Board records indicate daily fluctuations in water levels of about 2m, but diurnal variations are expected to be much larger than this. Calibration runs typically take several hours to complete, and during this period the reservoir may have been discharging or filling at a non-linear rate. There is no way that an operator can easily determine the water depth at the time of the calibration, and the water depths at the time of the original establishment of the range have not been published. Consequently the gravity differential over the range cannot be confidently expressed to better than about ± 0.05 mgal, with an upper limit of about ± 0.10 mgal being possible under extreme circumstances. It is therefore possible that errors of up to about ± 0.15% will be made in the determination of gravity meter scale constants. This error is large when compared with the sensitivity of modern gravity meters, and will be unacceptable to most operators.

The Illoura Avenue station is about 400m from the reservoir, and there is no measurable effect there from changing water levels in it. Operators can use this station with more confidence than with the Neringah Avenue station.

References

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ASEG-NEWS

Report on ASEG/ERF Course "High Resolution Seismic Techniques in Mining & Petroleum Exploration".

The ASEG and the Earth Resources Foundation within the University of Sydney co-sponsored a 2 day course on high resolution techniques on December 11 and 12, 1977. The course was conducted by Dr. John Farr of Western Geophysical Company, Houston, who has played a pioneering role in the development of high resolution seismic (HRS or HR) methods. The 55 or so members fortunate enough to attend the course were treated to an exceptionally clear and comprehensive exposition of the role, scope and viability of high resolution techniques; they will doubtless have no need for the following brief conspectus.

Dr. Farr came to us in Sydney directly from the Third IIASA* Conference on Energy Resources in Moscow, and so was able to introduce his course with an incisive synopsis of current international energy prognoses. The advent of the so-called "methanol economy", in which nuclear and/or solar energy is used to fuel chemical reactors which convert coal to methanol (suitable for instance for diluting petroleum) was a revelation to at least some of us. Whichever of the alternative energy technologies (palliatives?) are favoured, it would appear that the main thrust of energy search will remain within the realm of the geophysicist. High resolution seismic techniques in particular have application in many disparate aspects of energy strategy. Site evaluation for nuclear power plants, and for underground waste disposal/energy storage, are important areas of application. In the Australian context, the application of HRS techniques to both the resource evaluation and mine planning aspects of coal exploration is at present the primary attraction. However the range of application extends to the exploration for and evaluation of oil, gas and geothermal reservoirs, and concealed ore bodies, including uranium.

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The preliminary part of Dr. Farr's course was directed to elucidating the nature of resolution itself, based on a *relative* definition in terms of the thinnest disturbance (e.g. bed, fault) observable under given signal and noise conditions. The term 'high resolution' is likewise relative to the resolution inherent in 'conventional' seismic techniques. The key to improved resolution lies in maximising signal bandwidth and dominant frequency, and minimizing signal-generated and other noise. The substance of the course was devoted to the field and processing technologies and methodologies necessary for realization of these objectives.

It is widely recognized that explosive charges detonated below the geophysically weathered layer are the richest source of high frequencies available for seismic work. For high resolution, the smallest charges capable of providing the required penetration are preferred on the basis that the source spectra are displaced to higher frequencies.

The real novelty of Dr. Farr's approach to HR techniques lies in the detection and recording of reflected energy.

Recognizing that the seismic technique is effectively limited by the dynamic range of the recorder, the quest for higher resolution becomes crucially dependent on making the best use of the available dynamic range. (Dynamic range is itself limited essentially by the rate at which data bits can be transferred to a storage medium.) The available dynamic range can be used to best advantage when the combined response of the detectors and the transmission path is approximately white, and such a response can only be approached if the detectors compensate for the preferential attenuation of high frequencies on transmission through the earth. For this reason, variable electronic "response modifiers" are used to provide of order 40 db/octave shaping to detected ground motion, be it velocity, acceleration or a water-coupled pressure. In very high resolution work, detectors must also be beneath the highly absorptive weathered layer, with consequent cost escalation. Hydrophones are preferred to geophones or accelerometers because of the superior coupling of water and the ease of planting at depth.

With the availability of response modifiers at the detector level, high resolution recording is relatively straightforward. Custom-made high resolution recording equipment is only now becoming available, but conventional IFP recorders with optional high sample rates (2 or 4 kHz) and generous low-cut filtering (for additional spectral