Memo

To
Rijkswaterstaat, WVL

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From	**Direct line**	**E-mail**
John de Ronde	+31 (0)88 33 58 062	john.deronde@deltares.nl

Subject
Comparising management and processing of waterlevel measurements in The Netherlands and the UK

Introduction
The Rijkswaterstaat, WVL has asked Deltares to make a quick scan comparison on the management, processing and quality assurance of water level measurements in The Netherlands and the UK and to make some recommendations on these issues for the Netherlands.

The Netherlands
In the Netherlands the management, processing and quality assurance of water level measurements are the responsibility of Rijkswaterstaat. The water levels are measured with a floating device in a gauge station and send in a digital form to the database. The data are averaged over a 10 minute period.
In order to assure the stability in time of the water level measurements a stable reference point has been appointed in the vicinity of the gauge station. In most of the cases this is a separate pile in the gauge station itself founded on the Pleistocene sand layers in the underground. This pile is in no way connected to the station building in order to assure the stability of the pile and avoid vertical movement. A possible change in the height difference between the pile and the water gauge is checked every year and if necessary corrections are made to the data. A quality control of all the data of the tide gauges is performed on a regular basis by Rijkswaterstaat. The exact procedure concerning the quality assurance could not be found, this needs further attention. The water level data are stored in a central database of Rijkswaterstaat called DONAR. The data are made available via the urls:
http://www.rijkswaterstaat.nl/water/waterdata_waterberichtgeving/watergegevens/
http://live.waterbase.nl/waterbase_wns.cfm?taal=nl
Monthly and yearly means of 6 of the Dutch stations are contributed to the Permanent Service for Mean Sea Level (PSMSL) (http://www.psmsl.org/).

The United Kingdom
In the United Kingdom the network is owned by the Environment Agency and it is operated on their behalf by the Tide Gauge Inspectorate, which is based at the NOC (National Oceanography Centre) in Liverpool. The NOC was formerly the Proudman Oceangraphic Laboratory (POL). The network consists of 44 sites, almost all of which nowadays use bubbler pressure gauges as the primary sensors, equipped in many cases with half-tide sensors for datum control (Woodworth et al., 1996)(see also the appendix).

The NOC is responsible for the operation, maintenance and development of the tide gauge network, with the objectives of obtaining high quality tidal information through telemetry and to provide warning of possible flooding of coastal locations around the British Isles.

Data management

The data management is contracted to BODC by the Environment Agency.
The British Oceanographic Data Centre (BODC) has a special responsibility on behalf of NOC for the remote monitoring and retrieval of quarter hourly sea level data from the National Tide Gauge Network. Daily checks are kept on the performance of the gauges. Any problems arising at the remote sites can therefore be quickly identified by the interrogating computer and appropriate action taken to minimise data loss. The signals are processed to take account of water density, datum offset and calibration factors. The data are averaged over a 15 minute period, with the centre points being on the hour, 15, 30 and 45 minutes past the hour. The data are downloaded weekly. These are then routinely processed and quality controlled prior to being made available for scientific use. Data from 1993 onwards have been processed using the BODC in-house EDTEVA software, and are readily available. In addition to maintaining a databank of the 15 minutes values, several databases are available containing information about surges, maximum and minimum levels, mean sea levels, etc. Further details are available on the BODC web site (http://www.bodc.ac.uk). All UK data are contributed to the Permanent Service for Mean Sea Level (PSMSL) (http://www.psmsl.org/)

Datum control of the UK data

In order to measure long term sea level changes accurately, it is important to ensure that tide gauge instrumentation remains stable over time. This process is known as datum control and historically, it has been achieved by careful monitoring of tide gauge elevation relative to local benchmarks and datums. More recently, NOC researchers have developed additional instrumentation to do this, known as mid-tide sensors. In the appendix some more information can be found on the bubbler gauges and the mid-tide sensors (see appendix). Most of the gauges are related through the national levelling network to the Ordnance Datum of Newlyn.
In the PMSL database, where the monthly and yearly averaged mean sea level data are stored, there is a section with the Revised Local Reference (RLR). These are measured with respect to the same local land datum at each station, which are homogeneous and are the most suitable for time series analysis.

Datum control of the Dutch data, NAP change

In 2005 the Ordnance Datum in the Netherlands, the NAP (Normaal Amsterdams Peil), has been corrected due to the fact that changes in time of the NAP marks through the Netherlands and due to that also the differences between the NAP marks had become too big (several cm's). This also had an effect on the waterlevels, after 2005 they were measured to a changed reference frame. In order to derive a homogeneous dataset these corrections have to be made undone before these data can be used for the analyses of sea level rise, or any other analyses looking at changes in time. In this way (by undoing the NAP correction) the data are stored in the PMSL database (in the RLR section). So the databases DONAR and PMSL are for the Dutch data not the same and the data in DONAR are not homogeneous and can not be used for any analyse where time is involved.

Recommendations

This memo can only give a first glimpse concerning the comparison of the management, processing and quality assurance of water level measurements in The Netherlands and the UK. Discussion with the people of RWS and NOC is needed and further requirements have to be made made to get a better picture of the differences.

It is advised to make a document for the Rijkswaterstaat about the procedures that are followed by the Rijkswaterstaat accounting for the management, processing and quality assurance of water level measurements. E.g. the way in which the NAP correction has been performed in the water levels is not well documented.

It is advised to make a section in DONAR where homogeneous water level data can be found. It should be better made public that the waterlevel data in DONAR before and after 2005 are not homogeneous.

Appendix: Further information on bubbler gauges and Mid-tide sensors

Bubbler gauge
Most of the tide gauges in the current UK National Tide Gauge Network are bubbler systems. These consist of a metered flow of compressed gas (usually air), which is fed through a supply tube to an underwater cylinder located well below the lowest expected tidal level, so that it may experience the full tidal range.

Benchmarks and datums

In order to measure long-term sea-level changes accurately, tide gauge observations must be compared to a well-defined fixed level or datum. Benchmarks are commonly used for this purpose as they are located on a stable surface and are clearly marked by a brass bolt. The tide gauge benchmark (TGBM) is chosen as the primary benchmark for a specific tide gauge and is the datum to which sea-level observations are referenced at that site. However, because the stability of a particular benchmark cannot be guaranteed, it is good practice to measure the elevation of the tide gauge benchmark relative to a collection of at least three other local benchmarks and to check these periodically to ensure that they maintain these elevations relative to one another.

Tide gauge zero (TGZ)is the level at which the tide gauge would record zero water level and is defined relative to the elevation of the tide gauge benchmark. Typically (though not always), tide gauge zero equates to Admiralty Chart Datum (ACD), which is the lowest expected tidal level at a particular location and which can be considered as the level relative to which depths are shown on nautical charts and above which tidal levels are measured. It is convenient if TGZ equates to ACD, because this means that all tide gauge measurements should be positive.

It is often useful to express sea-level measurements at different locations relative to the same datum and in the UK, Ordnance Datum Newlyn (ODN) is used for this purpose. Observations of sea level relative to a benchmark were made using a tide staff at Newlyn every 15 minutes between 1915 and 1921, allowing mean sea level to be estimated for that six-year period. This mean level was established as Ordnance Datum Newlyn and was referenced to the elevation of the tide gauge benchmark. Land surveys conducted by the Ordnance Survey during the early 1900s were used to establish the elevation of other locations relative to the Newlyn Tidal Observatory benchmark, thus allowing all UK tidal monitoring points to be referenced to the same datum.

Mid-tide sensors

Datum control of underwater pressure transducers or bubbler systems can be difficult and consequently many of the tide gauges operated by NOC incorporate an additional pressure transducer or bubbler system, which is mounted midway between the estimated levels of the lowest and highest astronomical tides. As the measuring point of the mid-tide sensoris exposed for half of the tidal cycle, it can be levelled into the geodetic network and its tidal curve can then be fitted to those of the submerged full-tide sensors so that they too can be connected to the geodetic network. This allows precise datum control of the tide gauge records. For further details of this technique see Woodworth, P.l., Vassie, J.M., Spencer, R., Smith, D.E., 1996, Precise datum control for pressure tide gauges, Marine Geodesy, 19(1), 1–20 (1996).