



# Certificate of Analysis

## Standard Reference Material<sup>®</sup> 1640

### Trace Elements in Natural Water

This Standard Reference Material (SRM) is intended primarily for use in evaluating methods used in the determination of trace elements in fresh water. SRM 1640 is composed of natural fresh water collected from Clear Creek, CO, which has been filtered and stabilized with nitric acid at a concentration of 0.5 mol/L. A unit of SRM 1640 consists of approximately 250 mL of solution in a polyethylene bottle, which is sealed in an aluminized plastic bag.

**Certified Values and Uncertainties:** The certified values expressed as mass fractions and their expanded uncertainties are listed in Table 1 for 17 elements in SRM 1640. The certified values are equally weighted means of the results of two or more independent analytical methods or a single primary method. Each expanded uncertainty is based on a 95 % confidence interval for the mean, and includes an allowance for differences between the analytical methods used and an allowance for solution stability [1].

**Reference Values and Uncertainties:** The reference values expressed as mass fractions and their expanded uncertainties are provided in Table 2 for an additional ten elements. The reference values are means from a single method or two or more equally weighted means of results of independent analytical methods for which there is insufficient information to meet NIST certification criteria. Each expanded uncertainty is based on a 95 % confidence interval for the mean and includes an allowance for differences between the analytical method used and an allowance for solution stability but may not include all sources of uncertainty [1].

**Information Value:** The upper limit information value for thallium, expressed as a mass fraction in Table 3, is an estimate based on the instrumental limit of detection and measurements from a single unit of SRM 1640.

The analytical methods used for the characterization of this SRM are given in Table 4. All values are reported as mass fractions [2].

#### NOTICE AND WARNINGS TO USERS

**Expiration of Certification:** The certification of SRM 1640 is valid, within the measurement uncertainty specified, until **01 June 2010**, provided the SRM is handled in accordance with instructions given in this certificate (see "Instructions for Use"). This certification is nullified if the SRM is damaged, contaminated, or otherwise modified.

**Maintenance of SRM Certification:** NIST will monitor this SRM over the period of its certification. If substantive technical changes occur that affect the certification before the expiration of this certificate, NIST will notify the purchaser. Registration (see attached sheet) will facilitate notification.

Coordination of the NIST technical measurements was under the direction of J.R. Moody of the NIST Analytical Chemistry Division.

Statistical analysis of the experimental data was performed by W.F. Guthrie of the NIST Statistical Engineering Division.

Stephen A. Wise, Chief  
Analytical Chemistry Division

Robert L. Watters, Jr., Chief  
Measurement Services Division

Gaithersburg, MD 20899  
Certificate Issue Date: 06 February 2008  
*See Certificate Revision History on Last Page*

The overall coordination of measurements performed by the U.S. Geological Survey National Water Quality Laboratory, Arvada, CO, and by laboratories that participate in the Standard Reference Water Program was under the direction of K. Long.

Support aspects involved in the issuance of this SRM were coordinated through the NIST Measurement Services Division.

## INSTRUCTIONS FOR USE

The SRM should be shaken before use because of potential water condensation. Samples should be analyzed at a room temperature of  $22\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ . To prevent possible contamination of the SRM, pipettes should not be inserted into the bottle. After use, the bottle should be recapped tightly and returned to the aluminized bag, which should be folded and sealed with sealing tape. This precaution will protect the SRM from possible environmental contamination and long-term evaporation.

The mass fractions given in Tables 1 and 2 are expressed as microgram per kilogram or milligram per kilogram. These values can be converted to mass concentrations with units of nanograms per cubic centimeter or micrograms per cubic centimeter, respectively, by multiplying by the density. The density of SRM 1640 at  $22\text{ }^{\circ}\text{C}$  was measured to be  $1.0015\text{ g/cm}^3 \pm 0.0005\text{ g/cm}^3$  (identical to grams per milliliter).

Recognizing contamination at the microgram per kilogram level can be a serious problem, labware should be scrupulously cleaned and only high purity reagents employed. Sampling and manipulations, such as evaporations, should be done in a clean environment, such as a Class-100 clean hood.

Table 1. Certified Mass Fractions

Element	$\mu\text{g/kg}$	Element	$\mu\text{g/kg}$
Aluminum	52.0 $\pm$ 1.5	Iron	34.3 $\pm$ 1.6
Antimony	13.79 $\pm$ 0.42	Lead	27.89 $\pm$ 0.14
Arsenic	26.67 $\pm$ 0.41	Manganese	121.5 $\pm$ 1.1
Barium	148.0 $\pm$ 2.2	Molybdenum	46.75 $\pm$ 0.26
Beryllium	34.94 $\pm$ 0.41	Selenium	21.96 $\pm$ 0.51
Boron	301.1 $\pm$ 6.1	Silver	7.62 $\pm$ 0.25
Cadmium	22.79 $\pm$ 0.96	Strontium	124.2 $\pm$ 0.7
Chromium	38.6 $\pm$ 1.6	Vanadium	12.99 $\pm$ 0.37
Cobalt	20.28 $\pm$ 0.31		

Table 2. Reference Mass Fractions

Element	$\mu\text{g/kg}$	Element	$\text{mg/kg}$
Copper	85.2 $\pm$ 1.2	Calcium	7.045 $\pm$ 0.089
Lithium	50.7 $\pm$ 1.4	Magnesium	5.819 $\pm$ 0.056
Nickel	27.4 $\pm$ 0.8	Silicon	4.73 $\pm$ 0.12
Potassium	994 $\pm$ 27	Sodium	29.35 $\pm$ 0.31
Rubidium	2.00 $\pm$ 0.02		
Zinc	53.2 $\pm$ 1.1		

Table 3. Information Mass Fraction

Thallium &lt;0.1 µg/kg

**Source and Preparation of Material:**<sup>1</sup> A sample of about 3500 L of natural (fresh) water was obtained by the USGS at Clear Creek, CO. It was filtered through a 0.1 µm ultra filter and acidified with nitric acid. Analysis of the water by inductively coupled plasma mass spectrometry (ICPMS), before and after the stabilization process, showed that arsenic, beryllium, cobalt, selenium, and zinc were decreased in concentration during the stabilization process. These elements were adjusted to their original concentration levels by the addition of salts of the decreased elements. The stabilized solution was then pumped through an ultra filter, past a UV light source (for sterilization purposes), and then to a bottling station. At the bottling station, the bottles were rinsed with the sample and then filled.

Table 4. Methods Used for the Analysis of SRM 1640

Elements	Methods
Aluminum	DCP, ETAAS, ICP-AES, ICPMS
Antimony	ETAAS, Hyd-AAS, ICP-AES, ICPMS
Arsenic	ETAAS, Hyd-AAS, ICP-AES, ICPMS
Barium	DCP, ETAAS, ICP-AES, ICPMS, <b>ID-ICPMS</b>
Beryllium	ETAAS, ICP-AES, ICPMS
Boron	COLOR, ICP-AES, ICPMS, ID-TIMS
Cadmium	ETAAS, FAAS, IC, ICP-AES, ICPMS, ID-ICPMS
Calcium	DCP, FAAS, ICP-AES, ICPMS
Chromium	ETAAS, FAAS, IC, ICP-AES, ICPMS
Cobalt	ETAAS, ICP-AES, ICPMS
Copper	ETAAS, FAAS, IC, ICP-AES, ICPMS, ID-ICPMS
Iron	ETAAS, FAAS, ICP-AES, ICPMS, ID-TIMS
Lead	ETAAS, FAAS, IC, ICP-AES, ICPMS, <b>ID-ICPMS</b>
Lithium	ETAAS, FAAS, ICP-AES, ICPMS
Magnesium	DCP, FAAS, ICP-AES, ICPMS
Manganese	DCP, ETAAS, FAAS, ICP-AES, ICPMS
Molybdenum	ETAAS, ICP-AES, ICPMS, <b>ID-ICPMS</b>
Nickel	ETAAS, FAAS, ICP-AES, ICPMS, ID-ICPMS
Potassium	ETAAS, FAAS, FES, ICP-AES, ICPMS
Rubidium	ID-TIMS
Selenium	EAAS, Hyd-AAS, ICP-AES, ICPMS
Silicon	COLOR, ICP-AES, ICPMS
Silver	ETAAS, FAAS, ICP-AES, ICPMS, ID-ICPMS
Sodium	DCP, FAAS, FES, ICP-AES, ICPMS
Strontium	DCP, ETAAS, ICP-AES, ICPMS, <b>ID-ICPMS</b>
Thallium	ICPMS
Vanadium	ETAAS, ICP-AES, ICPMS
Zinc	FAAS, IC, ICP-AES, ICPMS, ID-ICPMS

<sup>1</sup>Certain commercial equipment, instrumentation, or materials are identified in this certificate to specify adequately the experimental procedure. Such identification does not imply recommendation or endorsement by the NIST, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

Methods given in bold indicate that a single NIST primary method was used for certification.

## Methods

COLOR	Colorimetry
DCP	Direct current plasma atomic emission spectrometry
ETAAS	Heated graphite atomizer (electrothermal) atomic absorption spectrometry
FAAS	Flame atomic absorption spectrometry
FES	Flame emission spectrometry
Hyd-AAS	Hydride generation-atomic absorption spectrometry
IC	Ion chromatography
ICP-AES	Inductively coupled plasma-atomic emission spectrometry
ICPMS	Inductively coupled plasma mass spectrometry
ID-ICPMS	Isotope dilution-inductively coupled plasma mass spectrometry
ID-TIMS	Isotope dilution-thermal ionization mass spectrometry

## Contributing Laboratories and Analysts:

E.S. Beary, M.S. Epstein, K.E. Murphy, P.J. Paulsen, and G.C. Turk; NIST Analytical Chemistry Division, Gaithersburg, MD

Water Resources Division and approximately 70 laboratories participating in the Standard Reference Water Program, under the direction of K. Long; U.S. Geological Survey, Arvada, CO

P. Taylor, L. Van Nevel, I. Lapitajs, A. Kynartren, A. Held, U. Örnemark, and P. De Bièvre; Institute for Reference Materials and Measurements, Geel, Belgium

M. Morita; Regional Environmental Division of the National Institute for Environmental Studies, Japan Environmental Agency, Tsukuba, Japan

## REFERENCES

- [1] ISO; *Guide to the Expression of Uncertainty in Measurement*, ISBN 92-67-10188-9, 1st ed. International Organization for Standardization: Geneva, Switzerland (1993); see also Taylor, B.N.; Kuyatt, C.E.; *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurements Results*, NIST Technical Note 1297, U.S. Government Printing Office: Washington, DC (1994); available at <http://physics.nist.gov/Pubs/>.
- [2] Taylor, B.N.; *Guide for the Use of the International System of Units (SI)*; NIST Special Publication 811, U.S. Government Printing Office: Washington, DC (1995).

**Certificate Revision History:** 06 February 2008 (Editorial change to correct the SRM number in Expiration section); 28 January 2008 (Update of expiration date and editorial changes); 20 January 2006 (This revision reflects an extension of the certification period); 17 March 2004 (This technical revision reports a change in the expiration date); 23 January 1998 (Revision reports the addition of an information value for thallium; 02 October 1997 (Original certificate date).

*Users of this SRM should ensure that the certificate in their possession is current. This can be accomplished by contacting the SRM Program at: telephone (301) 975-6776; fax (301) 926-4751; e-mail [srminfo@nist.gov](mailto:srminfo@nist.gov); or via the Internet at <http://www.nist.gov/srm>.*