

Gulf Monitoring Network Forum: Water Quality Parameter Data Dictionary

Water quality data is often generated from a wide range of monitoring efforts using program-specific methodologies. The methodologies utilized may not be easily accessible which can make using, synthesizing, or comparing water quality data across regions more difficult. The products developed for the RESTORE Council Monitoring and Assessment Program (CMAP; described in NOAA and USGS, 2019 and NOAA and USGS, 2020) can be used as resources to increase comparability and accessibility of water quality data. This data dictionary is based on the original water quality parameter glossary developed for CMAP and is intended to provide groundwork for the Alliance's Monitoring Network Forum to build upon. In many cases, monitoring programs only identified field instruments as the methods by which data is generated. Where possible, the analytical methods to which these field instruments adhere to are included below.

Algal toxins: A toxin produced by aquatic microorganisms mainly microalgae, dinoflagellates, and cyanobacteria. Algal toxins can be produced in large quantities during algal bloom events and can pose a serious environmental threat. Within the original CMAP application, the algal toxins parameter includes brevetoxins, microcystins, and domoic acid. Two analytical methods to measure algal toxins were identified. The most common was:

- **Enzyme linked immunosorbent assay (ELISA)**
 - Three different ELISA kits were identified: Abraxis Microcystins-ADDA test kit, Abraxis Cyindrospermopsin test kit, and Microtiter Plate ELISA for Microcystin
 - Units: µg/L
 - Concentration range: 0.01 - 5.00 µg/L
 - Number of programs: 4

Ammonia: A common form of nitrogen (NH₃) that exists in aquatic environments that can cause toxic effects on aquatic life. Ammonia is naturally produced through decomposition of organic matter, nitrogen fixation, as waste products from organisms, and other processes. This parameter can be reported as either NH₃ or NH₄⁺mass (mg/L) or as nitrogen mass per unit volume (mg N/l). This parameter includes data generated from both filtered and unfiltered samples. For more information, see <https://www.epa.gov/wqc/aquatic-life-criteria-ammonia>. A total of 28 analytical methods to measure ammonia were identified. The two most were:

- **EPA 350.1**
 - Units: mg-N/L
 - Concentration range: 0.01 - 2.0 mg-N/L
 - Number of programs: 25
- **SM 4500-NH₃ G**
 - Units: mg/L
 - Concentration ranges: 0.02 - 2.0 mg/L
 - Number of programs: 8

Ammonia + organic nitrogen: The total concentration of ammonia and organic nitrogen. In water chemistry, this summation is often used to express the amount of unoxidized nitrogen. This sum ($\text{NH}_3\text{-N} + \text{NH}_4^+\text{-N} + \text{Organic nitrogen as N}$), when expressed as nitrogen mass per unit volume, is often referred to as the total Kjeldahl nitrogen (TKN). This parameter includes data expressed as either compound mass or as nitrogen mass per unit volume, and includes the fractional results, dissolved (filtered), total (unfiltered), or suspended (unfiltered - filtered). Five analytical methods to measure ammonia + organic nitrogen in the Gulf of Mexico were identified. The most common was:

- **EPA 351.2**
 - Units: mg/L
 - Concentration range: 0.1 - 20 mg/L
 - Number of programs: 19

Chlorophyll: A green pigment that allows plants and algae to photosynthesize and can be used as a measure of the amount of algae or phytoplankton growing or the trophic condition of a waterbody. Within CMAP, the chlorophyll parameter includes all types of chlorophyll (i.e., A, B, C, etc.). Since phytoplankton produce chlorophyll and contain chlorophyll within their cells, phytoplankton and chlorophyll are very closely related terms, differing often only by methodology. Chlorophyll data, analyzed by various methods, are generally expressed as a mass of chlorophyll per unit volume, where phytoplankton data may be expressed by total biomass, biovolume, cell count, or diversity. Twenty-four analytical methods to measure chlorophyll were identified. The three most common were:

- **EPA 445.0**
 - Units: $\mu\text{g chl a/L}$
 - Concentration range: $\leq 250 \mu\text{g chl a/L}$
 - Number of programs: 29
- **SM 10200 H**
 - Units: $\mu\text{g/L}$; mg/m^3
 - Concentration range: Not found
 - Number of programs: 27
- **EPA 446.0**
 - Units: mg chl a/L
 - Concentration range: $\leq 27 \text{ mg chl a/L}$
 - Number of programs: 15

Conductance: Conductance is the measure of the ability of water to pass an electrical current. In addition to being the basis of most salinity and total dissolved solids calculations, conductivity is an early indicator of change in a water system. Most bodies of water maintain a fairly constant conductivity that can be used as a baseline of comparison to future measurements. Within CMAP, salinity is included in the detailed parameter of conductance. A total of 60 analytical and/or field methods to measure conductance were identified. The three most common were:

- **YSI 6 series multiprobe**

- Conforming to EPA 120.1, SM 2510B-1997, and ASTM Method D1125-95(99) (A)
- Units: mS/cm; ppt
- Concentration range: 0 - 100 mS/cm; 0 - 70 ppt
- Number of programs: 28
- **YSI multiprobe (unspecified)**
 - Conforming to EPA 120.1, SM 2510B-1997, and ASTM Method D1125-95(99) (A)
 - Units: Not found
 - Concentration range: Not found
 - Number of programs: 20
- **Florida Department of Environmental Protection (FDEP) SOP FT 1200**
 - Conforming to EPA 120.1
 - Units: $\mu\text{mhos/cm}$
 - Concentration range: Not found
 - Number of programs: 13

Cryptosporidium: A parasite present in fecal material with pathogenic effects in humans. No programs within the CMAP Inventory were identified as measuring this parameter.

Currents: The rate of movement in the water. A total of 18 analytical methods to measure currents were identified. The most common were:

- **RDI model 300S Sentinel Acoustic Doppler Current Profiler (ADCP)**
 - Units: m/s
 - Concentration range: ± 0.5 of measured velocity
 - Number of programs: 4
- **Aanderaa Doppler Current Sensor Acoustic Doppler Sampler**
 - Units: cm/s
 - Concentration range: 0 - 300 cm/s
 - Number of programs: 3

Cyanobacteria: A phylum of bacteria that obtain energy through photosynthesis, and are the only photosynthetic prokaryotes able to produce oxygen. Previously called "blue-green algae," they have since been renamed 'cyanobacteria' in order to avoid the term "algae", which in modern usage is restricted to eukaryotes. These bacteria can form dense mats and produce cyanotoxins, such as microcystin and domoic acid, that can be health hazards to humans and wildlife during harmful algal blooms. Cyanobacteria data, analyzed by various methods, are generally expressed as a mass cyanobacteria per unit volume, where phytoplankton data may be expressed by total biomass, biovolume, cell count, or diversity. No analytical methods to measure cyanobacteria were identified from the CMAP database.

Discharge: Rate of fluid flow passing a given point at a given moment in time. A total of 29 analytical and/or field methods to measure discharge were identified. The most common was:

- **SonTek FlowTracker Acoustic Doppler Velocimeter (ADV)**

- Units: ft³/sec; mgd
- Concentration range: NA
- Number of programs: 6

Dissolved oxygen: The amount of gaseous oxygen dissolved in water. Dissolved oxygen may be expressed as a concentration or as a percent saturation. Low dissolved oxygen is related to an excess of nutrients which can lead to excessive growth of vegetation. A total of 67 analytical and/or field methods to measure dissolved oxygen were identified. The two most common were:

- **YSI 6 series multiprobe**

- Conforming to EPA 360.1
- Units: mg/L; % saturation
- Concentration range: 0 - 50 mg/L; 0 - 500% air saturation
- Number of programs: 27

- **YSI multiprobe (unspecified)**

- Units: mg/L
- Concentration range: Not found
- Number of programs: 22

Enterococcus: A large bacterial genus present in human and animal feces and used as an indicator of fecal pollution of water bodies. *Enterococcus* are highly tolerant to wide ranges of temperature, pH and salinity. Six analytical methods to measure *Enterococcus* were identified. The two most common were:

- **SM 9230 D**

- Units: MPN/100 mL; Presence/Absence
- Concentration range: 1 - 2419 MPN/100 mL (97-well Quanti-Tray/2000); 1 - 200 MPN/100 mL (51-well Quanti-Tray)
- Number of programs: 15

- **EPA 1600**

- Units: CFU/100 mL
- Concentration range: Not found
- Number of programs: 12

Escherichia coli: A large and diverse group of bacteria found in the environment, foods, and intestines/feces of people and animals and used as an indicator of fecal pollution of water bodies. Seven analytical methods to measure *E. coli* were identified. The two most common were:

- **SM 9223-B**

- Units: MPN/100 mL; Presence/Absence
- Concentration range: 1 - 2419 MPN/100 mL (97-well Quanti-Tray/2000); 1 - 200 MPN/100 mL (51-well Quanti-Tray)
- Number of programs: 16

- **Coliscan Easygel**
 - Units: #/100 mL
 - Concentration range: Not found
 - Number of programs: 3

Fecal coliforms: A subset of total coliforms, fecal coliforms are distinguished by their tolerance for warmer temperatures. The fecal coliform group includes *Escherichia coli*. The fecal coliform parameter is used as a broad indicator of environmental contamination by human or animal waste. Seven analytical methods to measure fecal coliforms were identified. The two most common were:

- **SM 9222 D**
 - Units: CFU/mL; #/100 mL
 - Concentration range: 20 - 60 CFU/100 mL
 - Number of programs: 12
- **Alabama Department of Environmental Management (ADEM) SOP 5603 (rev 8)**
 - Units: MPN/mL; CFU/mL
 - Concentration range: 1 - 2419 MPN/100 mL (97-well Quanti-Tray/2000)
 - Number of programs: 5

Giardia: A protozoan parasite present in human and animal wastes that has pathogenic effects in both children and adults. No programs within the CMAP Inventory were identified as measuring this parameter.

Light attenuation: Light attenuation refers to the evaluation of the penetration of ambient sunlight below the water surface. A total of 16 analytical and/or field methods to measure light attenuation were identified. The two most common were:

- **Secchi disk**
 - Units: m
 - Concentration range: NA
 - Number of programs: 21
- **LI-COR light meter (unspecified)**
 - Units: Not found
 - Concentration range: NA
 - Number of programs: 19

Methylmercury: An organic form of mercury that acts as a bioaccumulative environmental toxicant. Methylmercury accumulates in fish tissue which is transferred to humans upon consumption. Four analytical methods to measure methylmercury were identified. The most common was:

- **EPA 1630**
 - Units: ng/L
 - Concentration range: 0.02 - 5 ng/L

- Number of programs: 2

Nitrate: Nitrogen in its fully oxidized form (NO_3), which is readily assimilated by plants and algae through photosynthetic processes. Excess nitrate in water can cause health problems in infants and contribute to eutrophication in water bodies. This parameter is reported as either nitrate mass per unit volume or as nitrogen mass per unit volume, and includes the fractional results: dissolved (filtered), total (unfiltered), or suspended (unfiltered - filtered). Thirty-two analytical methods to measure nitrate were identified. The two most common were:

- **EPA 353.2**
 - Units: mg/L
 - Concentration range: 0.05 - 10 mg/L
 - Number of programs: 10
- **EPA 300**
 - Units: mg/L
 - Concentration range: 0.42 - 14 mg/L
 - Number of programs: 5

Nitrite: Nitrogen in an intermediate form of oxidation (NO_2). Nitrite is further oxidized to nitrate through biological oxidation (nitrification). This parameter includes data expressed as either nitrite mass per unit volume or as nitrogen mass per unit volume, and includes the fractional results: dissolved (filtered), total (unfiltered), or suspended (unfiltered - filtered). Twenty-four analytical methods to measure nitrite were identified. Some of the monitoring programs identified nitrate analytical methods that could be modified to allow for measurement of nitrite. The two most common were:

- **EPA 353.2**
 - Units: mg/L
 - Concentration range: 0.05 - 10 mg/L
 - Number of programs: 13
- **EPA 300.0**
 - Units: mg/L
 - Concentration range: 0.36 - 12 mg/L
 - Number of programs: 5

Nitrite + nitrate: A measure of the combined concentrations of nitrite and nitrate. In water chemistry, this summation is often used to express the amount of inorganic nitrogen available for biological uptake. This parameter includes data expressed as either ion mass per unit volume or as nitrogen mass per unit volume, and includes the fractional results: dissolved (filtered), total (unfiltered), or suspended (unfiltered - filtered). Fifteen analytical methods to measure nitrite + nitrate were identified. The most common was:

- **EPA 353.2**
 - Units: mg-N/L
 - Concentration range: 0.05 - 10 mg-N/L

- Number of programs: 27

Organic carbon: The amount of carbon contained in organic compounds in water. The organic carbon parameter includes total organic carbon and dissolved organic carbon. Eighteen analytical methods to measure organic carbon were identified. The two most common were:

- **SM 5310 C**
 - Units: mg/L; µg/L
 - Concentration range: 0.1 - 4000 mg/L
 - Number of programs: 9
- **SM 5310 B**
 - Units: mg-C/L
 - Concentration range: Not found
 - Number of programs: 6

Orthophosphate: A term used to describe the phosphate molecule alone without any associated chemical species (PO_4^{3-}). Orthophosphate is readily consumable by the biological community and is usually the limiting factor of biological growth. This parameter includes data expressed as either PO_4^{3-} mass per unit volume or as phosphorus mass per unit volume, and includes the fractional results: dissolved (filtered), total (unfiltered), or suspended (unfiltered - filtered). Twenty analytical methods to measure orthophosphate were identified. The two most common were:

- **EPA 365.1**
 - Units: mg-P/L
 - Concentration range: 0.01 - 1.0 mg-P/L
 - Number of programs: 22
- **SM 4500-P E**
 - Units: mg-P/L
 - Concentration range: 0.01 - 6.0 mg-P/L
 - Number of programs: 6

pH: The negative logarithm of the hydrogen ion concentration of a solution that is used as a measure of the acidity or alkalinity of a liquid. Fifty-one analytical and/or field methods to measure pH were identified. The three most common were:

- **YSI 6 series multiprobe**
 - Units: pH units
 - Concentration range: 0 - 14
 - Number of programs: 17
- **pH meter (unspecified)**
 - Units: Not found
 - Concentration range: Not found
 - Number of programs: 16
- **YSI meter/datasonde (unspecified)**

- Units: Not found
- Concentration range: Not found
- Number of programs: 10

Phosphate: A phosphorus-containing anion that is often a limiting nutrient in environments (especially freshwater environments) and is widely used in fertilizers and detergents. This parameter includes data expressed as either ion mass per unit volume or as phosphorus mass per unit volume, and includes the fractional results: dissolved (filtered), total (unfiltered), or suspended (unfiltered - filtered). Six analytical methods to measure phosphate were identified. The most common was:

- **EPA 365.1**
 - Units: mg-P/L
 - Concentration range: 0.01 - 1.0 mg-P/L
 - Number of programs: 3

Phytoplankton: The term phytoplankton encompasses all photoautotrophic microorganisms in aquatic food webs. Phytoplankton serve as the base of the aquatic food web, providing an essential ecological function for all aquatic life. Phytoplankton are a diverse group that incorporates eubacterial and archaeobacterial prokaryotes and protistan eukaryotes. Note that phytoplankton and chlorophyll are very closely related terms. Chlorophyll results, analyzed by various methods, are generally expressed as a mass of chlorophyll per unit volume, where phytoplankton results may be expressed by total biomass, cell count, or diversity. Seven analytical methods to measure phytoplankton were identified. The two most common were:

- **N₂H₄CO₃ incorporation via incubation (Pennock and Sharp 1986)**
 - Units: µg/L
 - Concentration range: Not found
 - Number of programs: 2

Polycyclic aromatic hydrocarbons (PAHs): PAHs are a large family of compounds including anthracene, phenanthrene, tetracene, chrysene, and others that occur naturally in coal, crude oil, and gasoline. They are also often produced by incomplete combustion or processes that involve high pressure. Fifteen analytical methods to measure PAHs were identified. The most common was:

- **Gas chromatography/mass spectrometry (selected ion mode)**
 - Units: Not found
 - Concentration range: Not found
 - Number of programs: 2

Silicate: Silicate, or silicic acid (H₄SiO₄), is an important nutrient in the ocean and estuaries. Unlike other major nutrients such as phosphate, nitrate, or ammonium needed by almost all marine plankton, silicate is an essential chemical requirement for very specific biota, including diatoms, radiolaria, silicoflagellates, and siliceous sponges. These organisms extract dissolved

silicate from open surface waters for the buildup of their particulate silica (SiO_2), or opaline, skeletal structures. This parameter includes the fractional results: dissolved (filtered), total (unfiltered), or suspended (unfiltered - filtered). Ten analytical methods to measure silicate were identified. The most common was:

- **4500-SiO₂ D**
 - Units: mg/L
 - Concentration range: 0.04 - 2.0 mg/L
 - Number of programs: 3

Soluble phosphorus: Hydrated phosphate ions that are dissolved in water through weathering or in the production of fertilizers that plants can use. Soluble phosphorus is also called soluble reactive phosphorus. This parameter includes data expressed as either ion mass per unit volume or as phosphorus mass per unit volume. A total of 5 analytical methods to measure soluble phosphorus were identified. The two most common were:

- **Lachat Method 10-115-01**
 - Units: mg-P/L
 - Concentration range: 0.01 - 1 mg-P/L
 - Number of programs: 4
- **Lachat Method 10-115-01-A**
 - Units: mg-P/L
 - Concentration range: 0.1 - 2 mg-P/L; 1 - 20 mg-P/L
 - Number of programs: 4

Stage: The height of the water surface above an established datum plane. The commonly used datums are NAVD88 and NGVD29. A total of 20 analytical methods to measure stage were identified. The two most common were:

- **U.S. Geological Survey gage**
 - Units: ft
 - Concentration range: NA
 - Number of programs: 5
- **Electronic water level tape**
 - Units: ft
 - Concentration range: NA
 - Number of programs: 4

Suspended sediment concentration (SSC): A measure of how much sediment is suspended and transported in a body of water. Three analytical methods to measure suspended sediment concentration were identified. The most common were:

- **GF/C filtration/Weight (Strickland and Parsons, 1972)**
 - Units: mg/L
 - Concentration range: Not found

- Number of programs: 2

Total coliforms: A large group of bacterium which generally originate in the intestines of warm-blooded animals. This group includes *Citrobacter*, *Enterobacter*, *Hafnia*, *Klebsiella* and *Escherichia*. The total coliform parameter is used as a broad indicator of environmental contamination by human or animal waste. Ten analytical methods to measure total coliforms were identified. The two most common were:

- **ADEM SOP 5603 Rev 8: Fecal Coliform by Defined Substrate Technology—Multiple Well Procedure**
 - Units: MPN/mL; CFU/mL
 - Concentration range: 1 - 2419 MPN/100 mL (97-well Quanti-Tray/2000)
 - Number of programs: 4
- **SM 9222 B**
 - Units: CFU/mL
 - Concentration range: 20 - 80 CFU/100 mL; Maximum: 200 CFU/100 mL
 - Number of programs: 3

Total mercury: A measure of the concentration of mercury compounds, organic and inorganic in an environment or the tissues of an organism. Ten analytical methods to measure total mercury were identified. The most common was:

- **EPA 1631 E**
 - Units: ng/L
 - Concentration range: 0.5 - 100 ng/L
 - Number of programs: 9

Total nitrogen: The sum of organic nitrogen, nitrate (NO_3), nitrite (NO_2), and ammonia (NH_3), all expressed as N. Excess nitrogen in aquatic environments can result in eutrophication, algal blooms, and low levels of dissolved oxygen. This parameter includes data expressed as either compound mass per unit volume or as nitrogen mass per unit volume, and includes the fractional results: dissolved (filtered), total (unfiltered), or suspended (unfiltered - filtered). Total nitrogen is an estimated parameter since all components are analyzed using different methods. Twenty-four analytical methods to measure total nitrogen were identified. Many of the analytical methods identified from monitoring program protocol documents are not specifically total nitrogen methods, and instead are methods used to measure the components that can be used to generate total nitrogen values (e.g., total Kjeldahl nitrogen, nitrate-nitrite, or ammonia). The most common was:

- **EPA 353.2**
 - Units: mg-N/L
 - Concentration range: 0.05 - 10 mg-N/L
 - Number of programs: 6

Total phosphorus: A measure of the sum of all phosphorus compounds. This parameter includes data expressed as either compound mass per unit volume or as phosphorus mass per unit volume, and includes the fractional results: dissolved (filtered), total (unfiltered), and suspended (unfiltered - filtered). Sixteen analytical methods to measure total phosphorus were identified. The two most common were:

- **EPA 365.1**
 - Units: mg/L
 - Concentration range: 0.01 - 1 mg/L
 - Number of programs: 51
- **EPA 365.4**
 - Units: mg/L
 - Concentration range: 0.01 - 20 mg/L
 - Number of programs: 19

Total suspended solids (TSS): The dry weight of solids suspended in water that can be trapped by a filter. This can include silt, decaying plant/animal matter, sewage, industrial waste, etc. Twelve analytical methods to measure total suspended solids were identified. The most common was:

- **SM 2540 D**
 - Units: mg/L
 - Concentration range: Not found
 - Number of programs: 23

Turbidity: A measure of relative clarity of a liquid or how many particles are suspended in it. Often, turbidity is measured by illuminating the water with a light source of specific wavelength, the sensor measures the scatter of light, giving a measurement that is independent of ambient light. Due to the specificity of the instrument's light source and sensor, turbidity measurement from different models of turbidity sensors can vary significantly. Additional variation can be attributed to the use of different standards of calibration. To overcome this difficulty, many different unit designations have been created, each defined to a specific instrument type and method of calibration. Examples include Nephelometric Turbidity Unit (NTU), Formazin Nephelometric Unit (FNU) and many others. Measurements which share the same unit designation can be considered comparable, but are not readily comparable to other unit designations. For more information see, <https://water.usgs.gov/edu/turbidity.html> and <https://or.water.usgs.gov/grapher/fnu.html>. A total of 44 analytical methods to measure turbidity were identified. Many monitoring programs reported using secchi disks, secchi tubes, or turbidity columns to measure turbidity. In addition to these being field instruments, it could also be argued that they measure transparency rather than turbidity. The three most common were:

- **EPA 180.1**
 - Units: NTU
 - Concentration range: 0 - 40 NTU
 - Number of programs: 21

- **SM 2130 B**
 - Units: NTU
 - Concentration range: 0 - >1000 NTU
 - Number of programs: 18
- **Secchi disk**
 - Units: m
 - Concentration range: Not found
 - Number of programs: 18

Vibrio: Bacterial genus found in warm coastal waters that can cause human illness when raw/undercooked shellfish is contaminated or if an open wound is exposed to brackish/salt water. Six analytical methods to measure *Vibrio* were identified:

- **Polymerase chain reaction (PCR)**
 - Units: Not found
 - Concentration range: Not found
 - Number of programs: 1
- **Most Probably Number (MPN) Technique**
 - Units: MPN/g
 - Concentration range: Not found
 - Number of programs: 1
- **MPN real-time PCR**
 - Units: log MPN/g
 - Concentration range: Not found
 - Number of programs: 1
- **Enzyme immunoassay (EIA)**
 - Units: #/EIA well
 - Concentration range: Not found
 - Number of programs: 1
- **SYBR Gree 1 QPCR-MPN**
 - Units: Not found
 - Concentration range: Not found
 - Number of programs: 1
- **Direct Plating Method**
 - Units: Not found
 - Concentration range: Not found
 - Number of programs: 1

Water level: The height reached by the water in a waterbody. Fifty-one analytical and/or field methods to measure water level were identified. The most common were:

- **YSI 600 LS**
 - Units: ft
 - Concentration range: NA
 - Number of programs: 4

- **Wading rod**
 - Units: ft
 - Concentration range: NA
 - Number of programs: 4
- **Sounding reel**
 - Units: ft
 - Concentration range: NA
 - Number of programs: 4
- **Sounding line and weights**
 - Units: Not found
 - Concentration range: NA
 - Number of programs: 4
- **Sonic sounder**
 - Units: ft
 - Concentration range: NA
 - Number of programs: 4
- **Handline**
 - Units: Not found
 - Concentration range: NA
 - Number of programs: 4

Water temperature: A measure of water temperature. Water temperature can include temperature measures taken at the surface and throughout the water column. Fifty-three analytical and/or field methods to measure water temperature were identified. The most common was:

- **YSI 6 series multiprobe**
 - Conforming to EPA 170.1
 - Units: °C; °F; °K
 - Concentration range: -5 - 50°C
 - Number of programs: 27

References

NOAA and USGS. 2019. Council Monitoring and Assessment Program (CMAP): Inventory of Existing Habitat and Water Quality Monitoring, and Mapping Metadata for Gulf of Mexico Programs. National Oceanic and Atmospheric Administration and U.S. Geological Survey. NOAA Technical Memorandum NOS NCCOS 262. Silver Spring, MD. 155 pp. doi: 10.25923/gwpx-ff30

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