Appendix D. Glossary, by Laura Carbognin and Working Group

The purpose of this glossary is to explain the meaning of terms currently recurring in studies on land subsidence due to ground-water withdrawals. Because this volume is for readers with diverse backgrounds and for interested untrained personnel, the definitions given here are simplified. For a more detailed explanation, the bibliography suggests some books which will help the reader.

AQUICLUDE

An areally extensive body of saturated but relatively impermeable material that does not yield appreciable quantities of water to wells. Aquicludes constitute boundaries of aquifer flow systems; term is synonymous with confining bed.

AQUIFER

An areally extensive body of saturated permeable material that will yield significant quantities of water to wells and springs. An aquifer includes the unsaturated part of the permeable body. Aquifers may be classed as unconfined or confined, depending upon the presence or absence of a water table. An aquifer may also be called a water-bearing stratum. Unconsolidated alluvial deposits of sand and gravel, porous sandstones, or fractured limestones are examples of water-bearing formations

AQUIFER SYSTEM

A heterogeneous body of interbedded permeable and poorly permeable layers that functions regionally as a water-yielding hydraulic unit. It comprises two or more aquifers (permeable formations) separated by laterally discontinuous aquitards that locally impede ground-water movement but do not greatly affect the overall hydraulic continuity of the system.

AQUITARD

A saturated, but poorly permeable, bed that locally impedes ground-water movement and does not yield water freely to wells, but which may transmit appreciable water, to or from adjacent aquifers.

ARTESIAN

The term artesian derives from Artois (Lat. Artesium), a northern province of France where naturally flowing wells were drilled in 1750. Today the term artesian is applied to any well tapping a pressure aquifer or simply to the aquifer itself. Artesian is synonymous with confined.

ARTESIAN AQUIFER

An aquifer in which the water level rises above the base of the upper confining bed when penetrated by a well. In recent years artesian aquifer has been used as a synonym for confined aquifer.

BENCH MARK

A relatively permanent mark, natural or artificial, furnishing a survey point at a known elevation in relation to an adopted datum. Bench marks, or marked points, connected by precise leveling, constitute the control of land-surface settlement.

COEFFICIENT OF COMPRESSIBILITY (L^2F^{-1})

Compressibility is the aptitude of the soil to be deformed. It is expressed by means of a coefficient which is the ratio between a void ratio decrease from e_o to e and an increase in effective stress. The value $a_v = e_0\text{-}e\Delta p$ represents the coefficient of compressibility for the range p_0 to $p_0 + p$. Units usually are cm^2kg^{-1}.

COEFFICIENT OF VOLUME COMPRESSIBILITY (L^2F^{-1})

The compression of a clay (aquitard) per unit of original thickness, due to a unit increase of effective stress, in the load range exceeding preconsolidation stress. It is expressed by the equation

$$m_v = \frac{a_v}{1 + e_0}$$

in which e_0 is the initial void ratio. Units usually are $cm^2\ kg^{-1}$.

COMPACTION

A decrease in the volume of a mass of sediments from any cause. In this guidebook, compaction is defined as the decrease in the thickness of sediments, as a result of an increase in vertical compressive stress, and is synonymous with "one-dimensional consolidation," as used by engineers. The term compaction is applied both to the process and to the measured change in thickness.
In thick fine-grained beds, compaction is a delayed process involving the slow escape of pore water and the gradual transfer of stress from neutral to effective. Until sufficient time has passed for excess pore pressure to decrease to zero, measured values of compaction are transient.

COMPACTION, RESIDUAL

Compaction that would occur ultimately if a given increase in applied stress were maintained until steady-state pore pressures were achieved, but had not occurred as of a specified time because excess pore pressures still existed in beds of low diffusivity in the compacting system. It can also be defined as the difference between (1) the amount of compaction that will occur ultimately for a given increase in applied stress, and (2) that which has occurred at a specified time.

COMPACTION, SPECIFIC (L^3F^{-1})

The decrease in thickness of deposits, per unit of increase in applied stress, during a specific time period.

CONE OF DEPRESSION

A cone of depression in the water table, developed around a pumping well and extending throughout the area of influence of a well (also see drawdown). For an artesian aquifer, this can be called the "cone of pressure relief" (Tolman, 1937).

CONFINED AQUIFER

Same as artesian aquifer.

CONSOLIDATION

The gradual reduction in the water content (void ratio) of a saturated soil, as a result of an increase in the pressure acting on it, because of the addition of overlying sediments or the application of an external load. A laboratory test called a one-dimensional consolidation test (odometric test), is performed on soil samples to evaluate consolidation. From such a test the coefficient of consolidation, c_v, usually reported in cm^2sec^{-1}, is calculated as the ratio

$$c_v = \frac{K}{m_v \gamma_w}$$

where K is the hydraulic conductivity, m_v is the coefficient of volume compressibility, and γ_w is the unit weight of water. The theory of consolidation, developed by Terzaghi, leads to a relation between degree of consolidation and time:

$$U\% = \frac{c_v t}{H^2}$$

In this expression U is the degree of consolidation, that is, the percentage of total consolidation occurring in some time t; c_v is the coefficient of consolidation; and H is half of the sample's thickness when the odometric test is performed.

DRAWDOWN

As water is withdrawn from an aquifer by a pumped well, the ground-water level is lowered. Drawdown is the distance the water table or pressure surface is lowered at a given point (see also cone of depression).

EXTENSOMETER

An instrument used for measuring vertical deformation of fine-grained beds in the subsoil under stress. Vertical extensometers commonly are installed when land subsidence follows ground-water withdrawal. Extensometers also are used to measure small horizontal displacements.

HEAD, HYDRAULIC, OR STATIC

The static head is the height, referred to a standard datum, of the surface of a column of water that can be supported by the static pressure at a given point. The static head is the sum of the elevation head and the pressure head.

HYDRAULIC CONDUCTIVITY, K (LT^{-1})

If a porous medium is isotropic and the fluid is homogeneous, the hydraulic conductivity of the medium is the volume of water at the existing kinematic viscosity that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. In the metric system it may be expressed in cm sec^{-1}; in English units it may be expressed in feet day^{-1} (see also permeability).

HYDRAULIC GRADIENT

The change in static head per unit of distance in the direction of the maximum rate of decrease in head if not specified. If different, direction is specified.

HYDROCOMPACTION

The process of volume decrease and density increase that occurs when moisture-deficient deposits compact as they are wetted for the first time since burial. This type of land settlement has also been called "shallow subsidence."

LAND SUBSIDENCE

Sinking or settlement of the land surface, due to diverse causes and generally occurring on a large scale. Usually the term refers to the vertical downward movement of the land surface although small-scale horizontal movements may be present. The term does not include landslides which have large-scale horizontal displacements, or settlement of artificial fills.

PERMEABILITY

The capacity of rock or soil to transmit fluid under the combined action of gravity and pressure. Permeability is expressed as the velocity with which water, under the influence of a given difference in head, passes through a porous medium having a certain cross section and thickness. Permeability is dependent on the size and shape of the pores of the porous medium and it can be reduced by compaction (see also hydraulic conductivity).

PHREATIC AQUIFER

Same as unconfined aquifer.

PHREATIC SURFACE

Same as water table.

PIEZOMETRIC SURFACE

An imaginary surface coinciding with the head of the water in an aquifer. (Also see potentiometric surface.)

POTENTIOMETRIC SURFACE

A surface which represents the static head. As related to an aquifer, it is defined by the levels to which water will rise in tightly cased wells (USGS) Also called piezometric surface in many countries.

REBOUND

An upward movement of soil as a consequence of a decrease in effective stress. In fine-grained soils, rebound is usually much less than the amount of compaction, since the latter is mostly irreversible.

RECOVERY

The water-level rise in a well occurring upon the cessation of discharge from that well or a nearby well.

STRESS, APPLIED (FL^{-2})

The downward stress imposed at an aquifer boundary. It differs from effective stress in that it defines only the external stress tending to compact a deposit rather than the grain-to-grain stress at any depth within a compacting deposit.

STRESS, EFFECTIVE (FL^{-2})

Stress (pressure) that is borne by and transmitted through the grain-to-grain contacts of a deposit, and thus affects its porosity or void ratio and other physical properties. In one-dimensional compression, effective stress is the average grain-to-grain load per unit area in a plane normal to the applied stress. At any given depth, the effective stress is the weight (per unit area) of sediments and moisture above the water table, plus the submerged weight (per unit area) of sediments between the water table and the specified depth, plus or minus the seepage stress (hydrodynamic drag) produced by downward or upward components, respectively, of water movement through the saturated sediments above the specified depth. Thus, effective stress may be defined as the algebraic sum of the two body stresses, gravitational stress and seepage stress. Effective stress may also be defined as the difference between geostatic and neutral stress.

STRESS, GEOSTATIC (FL^{-2})

The total load per unit area of sediments and water above some plane of reference. It is the sum of (1) the effective stress and (2) the neutral stress.

STRESS, NEUTRAL (FL^{-2})

Fluid pressure exerted equally in all directions at a point in a saturated deposit by the head of water. Neutral pressure is transmitted to the base of the deposit through the pore water, and does not have a measurable, influence on the void ratio or on any other mechanical property of the deposits.

STRESS, PRECONSOLIDATION.(FL^{-2})

The maximum antecedent effective stress to which a deposit has been subjected, and which it can withstand without undergoing additional permanent deformation. Stress changes in the range less than the preconsolidation stress produce elastic deformations of small magnitude. In fine-grained materials, stress increases beyond the preconsolidation stress produce much larger deformations that are principally inelastic (nonrecoverable).

STRESS, SEEPAGE (FL^{-2})

When water flows through a porous medium, force is transferred from the water to the medium by viscous friction. The force transferred to the medium is equal to the loss of hydraulic head. This force, called the seepage force, is exerted in the direction of flow.

SUBSIDENCE/HEAD-DECLINE RATIO

The ratio between land subsidence and hydraulic head decline in the coarse-grained beds of the compacting aquifer system.

UNCONFINED AQUIFER

A geologic formation of permeable material that has a water table as the upper surface.

WATER TABLE

The upper surface of the zone of saturation in a phreatic aquifer in which the pressure is atmospheric.

WELL, ARTESIAN

A well that takes water from a pressure water body.

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