Week One

I. Introduction
   A. introduce instructor
   B. review syllabus

II. What is hydrogeology
   A. the study of interactions between water and geologic materials
      1. i.e., flow through rock and dirt
      2. involves both physics and chemistry
   B. subset of hydrology (study of planetary water)
   C. applications of hydrogeology
      1. water supply
         a) locating
         b) developing
         c) allocating between users
         d) protecting
            (1) contamination
            (2) safe extraction rate
         e) remediation
      2. water disposal
         a) temporary (excavation)
         b) permanent
            (1) tunnels
            (2) agricultural drainage
            (3) land reclamation

III. Basic geologic premises important to hydrogeology
   A. natural system is heterogeneous
      1. geologic variability is found at all scales
      2. geology of the system cannot be ignored
   B. many system parameters are unknown
      1. our knowledge of subsurface is minuscule
      2. we have a limited window into the geologic properties
      3. the time scale of our observations/interest is often short
      4. processes relevant to hydrogeology may be quite slow

IV. The wet planet
   A. Earth is the only planet known to have liquid water
      1. others may have had water in the past
      2. Mars, and the outer planets may have ice
   B. water is required for life as we know it
      1. Americans use 200-300 l per day (personal)
      2. total US usage is ~1000l/day (includes industrial/agricultural)
      3. agriculture and industry are biggest consumers
4. usage increases with industrialization
5. US per capita usage is declining
   a) maybe we're learning?
   b) transition from agriculture to industrial?
C. distribution of water on earth
   1. ~97% oceans
   2. ~2% glaciers and ice caps
   3. ~0.6% groundwater
   4. ~0.01% surface fresh water
   5. ~0.001% atmosphere

V. origin of earth’s water (current hypothesis)
A. solar system begins as whirling cloud of dust and gas
   1. mostly helium and hydrogen
   2. smattering of heavier elements
B. sun, planets, and moons condense
   1. sun has enough mass to start fission
   2. heat from the sun warms planets
C. proto-atmosphere
   1. driven off by hot inner planets including earth
   2. retained by cooler outer planets
D. earth collapses and heats
   1. molten iron heads to the center
   2. lighter materials migrate upwards
E. volcanic activity releases water, gases
   1. water was chemically bound in minerals
   2. produces atmosphere, oceans, etc.
   3. require several billion years at current rates
      a) earth was probably more active
F. photosynthesis modifies atmosphere

VI. Hydrologic cycle
A. moves water around the planet
   1. virtually a closed system
   2. endless cycle
   3. driven by solar energy
   4. water also moves heat around the planet
      a) advection
         (1) gulf stream, El Nino
      b) phase changes
         (1) evaporation cools
         (2) condensation releases heat
         (3) both involve ~590 cal/g
         (4) melting of ice requires about 80 cal/g
B. water enters atmosphere as vapor
   1. processes producing vapor
a) evaporation  
   b) sublimation  
   c) transpiration  

2. change of state purifies water  
   
   C. leaves the atmosphere as precipitation/condensation  
      1. rain  
      2. snow  
      3. frost  

D. on land  
   1. water flows in response to gravity towards  
      a) oceans  
      b) internal sinks  
      2. processes  
         a) overland flow  
         b) infiltration  
         c) interflow  
         d) groundwater  
      3. chemical effects  
         a) water picks up dissolved solids  
         b) oceans would originally have been fresh  

E. exit/entry from cycle  
   1. juvenile water from volcanoes  
   2. chemically bound into minerals  
   3. currently these two are ~balanced  
   4. not necessarily true in the past  

F. lots of shortcuts in the cycle  

VII. Hydrologic equation  
   A. input minus output equals change in storage  
      1. simple but crucial  
      2. also known as continuity or mass balance  
      3. water is essentially incompressible  
         a) means we can track volume  
         b) much easier to measure than mass  
         c) must use mass for compressible fluids  
   
   B. swimming pool example  
      1. inputs  
         a) water added from tap  
         b) rain  
         c) biologic inputs  
      2. outputs  
         a) evaporation  
         b) splash  
         c) on swimmers  
      3. change in storage
a) pool level

C. hydrologic problems
1. requires definition of boundaries
   a) not easy
2. estimate mass transfer across boundaries
   a) often very difficult
3. deal with transient behavior
   a) water moves slowly
   b) we may only see a small interval
   c) time scale greater than ours
   d) need to compare appropriate estimates

D. hydrologic systems
1. surface water
   a) usually consider basins
      (1) defined by topographic divides
   b) closed basins (desert southwest)
      (1) precipitation
      (2) transpiration
      (3) evaporation
      (4) storage
      (5) groundwater
   c) open basins
      (1) rivers complicate the problem
2. groundwater
   a) ground-water divide
      (1) crest of water table or potentiometric surface
      (2) hard to locate
         (a) limited subsurface data
         (b) muted topography
      (3) not fixed in time

VIII. Units and significant digits
A. units
1. most quantities have units attached
2. numbers are meaningless without the units
3. answers will be wrong without the units
4. good practice is to track units through a problem
B. significant digits
1. this refers to the precision of your answers
2. can only be as good as the lowest precision input
3. exact numbers do not affect significant digits
   a) constants and conversion factors
4. answers with too many/few sig. digits will be wrong

IX. ASTM
A. American Society of Testing and Materials
B. publishes guides for testing various materials
C. for many purposes these are industry standards
D. value
   1. allows direct comparison between measurements
   2. often legally defensible as standard engineering practice
   3. simplifies reporting
E. limitations
   1. not all hydrologic measurements have an ASTM procedure
   2. not always the most accurate method