Literature Search

I. Definitions of Depth Filtration
   a. Multiple layers or a single layer of medium that captures particles within its structure (Sterlitech)
   b. Layers of filtration media with different sizes and densities (Culligan)
   c. Particles are trapped throughout the filter bed, not just in the top few inches (on the surface) (Culligan)
   d. Removes particles by attaching them to media or previously retained particles (Farizoglu)
   e. Because of the particle/pore size ratio, particles smaller than the pores are captured during depth filtration; particles larger than the pore size get stuck at the entrance to the filter ("sieving") which is classified as surface filtration (Wyckomar)
   f. **Head loss** (definition): measure of the reduction in the total head of the liquid as it moves through a system. The total head is the sum of the elevation head, velocity head and pressure head (Mountain Empire Community College)

II. Current Knowledge of How Depth Filtration Occurs
   a. **Binding:** tendency of certain substances to stick to filter medium, usually based on **charge** (Sterlitech)
   b. **Physical/Chemical Properties** that cause adherence between particles and filtration medium (Lau)
   c. **Electrostatic or van der Waals attraction** between the particle and medium; once charge on medium is neutralized, continued deposition at lower efficiency (Lau)
   d. "Rapid sand filters use a much higher velocity of 5-15 m/h and do function by depth filtration within the bed." (Sutherland)
   e. When raw water passes through the filter bed, particles are deposited inside its pores, reducing pore size and coincidentally increasing the filter bed's resistance to the flow. This also causes a rise in local liquid velocity, which pulls previously deposited particles from the filter bed back into the effluent. (Farizoglu)

III. How Depth Filtration Relates to Other Factors
   a. **Pressure drop** throughout the filter increases as suspended particles accumulate in the filter bed (Culligan). Initial head loss occurs when turbidity-free water passes through the clean filter bed. Head loss increases with time during operation and also increases proportionally with the square of the flow rate. (Farizoglu)
   b. **Effective sizes and shapes of sand grains** have strong correlation between depth of the sand bed and efficiency of removing particles. (Jusoh) Increasing the size of the grains results in a decrease in head loss, but also decreases the turbidity removal rate. (Farizoglu)
   c. **Depth of filter bed**: increasing depth of the filter leads to an increase in head loss because of greater surface area, which also improves the efficiency of the filter (Farizoglu)

d. **Volume of Deposit** is key factor for describing head loss and steady state removal characteristics; smaller particles form high volume deposits (Balasubramaniam)

IV. Head Loss
   a. Particles filtered at the **surface** (cake surface filtration): rapid head loss develops, leading to shorter filter runs, and the head loss vs. time is exponential (Benth)
   b. Particles filtered **within the bed** (depth filtration): head loss increases linearly with time and with solid accumulation; promotes longer filter runs (Benth)

V. Subsurface Injection of Water into Sand Filters
   a. Edge of Knowledge? – Meeting scheduled with Jim Bisogni to learn more about this idea

Sources

"Basics of Filtration." *Wyckomar UV Water Purification.* Wyckomar Inc. Web. 16 Feb. 2013. http://www.wyckomaruv.com/PDFs/Basics%20of%20Filtration.pdf

Balasubramaniam, Vigneswaran. "Effect of particle size in depth filtration: Measurements and modeling." *Electronic Doctoral Dissertations for UMass Amherst.* (January 1, 1997). Paper AAI9737593. Web. 20 Feb. 2013. <http://scholarworks.umass.edu/dissertations/AAI9737593>

Benth, Bryant et al. "Evaluation of Wastewater Filtration." *Utah Water Research Laboratory.* Utah State University (1981). Web. 20 Feb. 2013.

Farizoglu, Burhanettin. "The performance of pumice as a filter bed material under rapid filtration conditions." *Filtration & Separation* 40.3 (April 2003): 41-47. Web. 13 Feb. 2013.

"Fundamentals of Particle Removal by Depth Filtration." Culligan. Web. 13 Feb. 2013. <www.culliganmiami.com/pf4.html>

"Head Loss." *Water/Wastewater Distance Learning Website.* Mountain Empire Community College. Web. 20 Feb. 2013. <http://water.me.vccs.edu/courses/CIV240/lesson7.htm>

Jusoh, Ahmad. "Effective depth, initial head loss and backwashing criteria as the key factors of burned oil palm shell (BOPS) granular filtration." *Desalination and Water Treatment* 10.1-3 (2009): 80-86. Web. 13 Feb. 2013.

Lau, Boris L T. "Physicochemical aspects of Cryptosporidium surrogate removal in carbon block filtration." *American Water Works Association Journal* 97.2 (Feb. 2005): 12, 92-101. Web. 13 Feb. 2013.

"Principles of Filtration." Sterlitech Corporation. Web. 13 Feb. 2013. <www.sterlitech.com/principles-of-filtration>

Pourrezaei, Parastoo. "Physico-Chemical Processes: Water Environment Research, 2010 Literature Review." Water Environment Federation. Web. 13 Feb. 2013.

Sutherland, Ken. "Depth filtration: Efficient separation processes through depth filtration." *Filtration & Separation* 48.5 (Sept.-Oct. 2011): 12-15. Web. 13 Feb. 2013.