# VSEP Vibes Newsletter

## Welcome to the New Logic Research Newsletter

**Engineering is an Art**

Art is a wide range of cultural activities centered around creations that utilize imaginative talents. The Art is intended to evoke interest through an emotional reaction, a conceptual idea, technical proficiency, or simple beauty. The basic concept of Art is creativity. And what is truly art is in the eye of the beholder. Engineering can create awe inspiring inventions that stimulate wonder and amazement. Examples of these include the Eiffel Tower, the Hoover Dam, and the Egyptian pyramids. Dr. Einstein once said you should make things as simple as possible, but not simpler. We like to think of our VSEP technology as a unique creation that represents simplicity, form, and function. We have had mechanical engineers who have studied resonance their whole life look at our machine with amazement when they see the simple design.

New Logic has developed a proprietary reverse osmosis membrane system that is unique. Since the creation of this new vibratory membrane filtration system, many new applications for membrane filtration have been found. Previously, many applications would not be possible with conventional membrane systems or would be fraught with problems. Since the advance of the "Vibratory Shear Enhanced Process" known as VSEP, new opportunities for membrane filtration have come about. New Logic manufactures both the conventional spiral RO membrane systems as well as the unique vibratory VSEP membrane filtration. We design, build, and supply conventional spiral RO membrane systems when they are appropriate, and when they are not, we provide VSEP equipment for the more difficult and fouling prone applications.

VSEP's unique separation technology is based upon an oscillating movement of the membrane surface with respect to the liquid to be filtered. The result is that blinding of the membrane surface due to the build up of solids is eliminated and access to the membrane is provided to the liquid to be filtered. The shear created from the lateral displacement causes suspended solids to be repelled and held in suspension above the membrane surface. This combined with laminar flow of the fluid across the membrane surface keeps the filtered liquid homogeneous and allows very high levels of recovery of filtrate from the feed material. Even though the design looks very simple, the details of fabrication are very complex and hidden. We have had clients look at the machine in operation and claim that they could build that in their garage. The beauty of the VSEP is that it appears very simple, but, it is far more highly engineered to perform under very demanding conditions.

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**Coal is an Economical Form of Energy**

Coal is mined all over the world. It has been harvested in Appalachia for a long time. The economies of West Virginia, Ohio, and Pennsylvania are highly dependent on this industry. Much of the mining in this area is surface mining where large excavations are done to remove the over-burden of soil to get to the layers of Coal. Then the coal is dug out and hauled away. What results are large pits and these can collect water from rain, run-off, or springs. This water will absorb metals, organics, and other pollutants from the coal seam. This water is then pumped out and eventually discharged to creeks and rivers.

The primary concern domestically is that Selenium is found in abundance in coal deposits. There are also metals such as Nickel, Cobalt, and Zinc. These can all leach into the pit water and can be a problem when discharged. Even though it is a bio nutrient for humans and is often taken as a supplement, Selenium can cause problems for avian species. In California, Selenium was accumulating in a wetland at the Kesterson Reservoir where migratory birds would and build nests. It was found that Selenium was causing weak egg shells that led to low birth rates for hatchlings and the bird population suffered as a result. As a result of this, the EPA made a Selenium rule limiting Se discharge to <4.7 parts per billion (ppb).

New Logic conducted three onsite pilot tests at coal surface mines in West Virginia. Each of these had Selenium levels of about 50 ppb. These coal mines were ordered to comply with the new rule and to test certain technologies that are known to remove Selenium. One was a digester system known as Abmet. The other was a steel wool adsorber that could grab Selenium. This third was our VSEP system because of our known Selenium removal at a refinery processing heavy crude. Two of these mines discharged to the Rum Creek, a tributary of Guyandotte River. The other mine was discharging to the Mud River. These coal mines were discharging 800, 175, and 500 gpm of pit water to these creeks and rivers.

The study was also set up to be run over a four month period so that testing would occur during periods with variations in the characteristics of the pond water. One main objective was to verify consistent performance over time both in terms of consistent and repeatable throughput capacities as well as filtered water quality that was able to meet the discharge requirements stated.

Because the flow rates would be large, a two stage scenario was testing. The fairly dilute water was run through a first stage VSEP with RO at a recovery rate of 80% in single pass with a flux rate of 55 GFD (gallons per square foot per day). Then, the concentrate from this was filtered in a second stage VSEP using RO at a recovery rate of 75% at a flux rate of 28 GFD. This results in an overall recovery of 95% leaving a concentrate stream that is only 5% of the initial volume. This concentrate could then be evaporated. Many samples were collected during testing. The feed values of Se varied from 42 to 50 ppb. All of the VSEP permeate samples were less than 1 ppm, far below the 4.7 ppb limit required. No pretreatment was done. There was only wire mesh screening to remove the frogs and snakes.

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**Is our Water Resource Sustainable**

Something is sustainable if it can continue into the future without problems or disruptions, Sustainability has become to be known as a social goal to use resources wisely and to look for alternatives when possible. The resources we have on this planet are fixed, but our population and our use of consumer goods continues to increase. There are only so many minerals on the planet. Phosphate is only found in a few places in the world including Jordan, Morocco, and Florida. When these deposits are exhausted finding Phosphorous for fertilizer will be more difficult. Someday peak oil will happen and more crude oil cannot be produced. Water also is limited although it is used once and then recirculates in the environment. Only 0.5% of the water on the planet is fresh water that is drinkable.

Sustainability is a goal of many companies. They all include website information about all the wonderful things they are doing to reduce and reuse. Many of the large companies even have a vice president of Sustainability. They all talk about doing the right thing, but in my experience in doing water projects it really comes down to economics and if there is a side-benefit of water reuse or conservation it is a plus but not given its full merit. Previously, I talked about a winery in California that was pumping 1000 gpm out of the aquifer and then using it once and throwing it away. This is in a state where water wars rage and water scarcity is a big deal. Water is used to make everything that we consume. It is not just watering crop and washing our clothes. Nearly every single thing that is produced uses water. It takes twice as much water to produce a plastic water bottle as the bottle contains when sold. This is all hidden and people don't often think about this aspect. Here is a list of some consumer goods and how much water it takes to make them:

| | |
|---|---|
| Car | 20,000 gallons |
| Leather Shoes | 2,113 gallons |
| Smartphone | 3,190 gallons |
| A Pair of Jeans | 2,866 gallons |
| Cotton Bed Sheets | 2,576 gallons |
| Cotton T-shirt | 659 gallons |
| One sheet of Paper | 1.3 gallons |
| One Gallon of Wine | 7 gallons |

New Logic has done many projects to improve water sustainability. In the bottled water industry, we have installed VSEP equipment that can increase the water yield from 80% to 98%. We have installed cooling tower projects where the blowdown brine can be filtered and recycled as make up water. Water reuse from wastewater will have psychological issues when the subject of drinking water or potable water is brought up. But this really is only a small portion of all the water that is taken for use. Polymeric membranes that were created in the 1960s allow for this water reuse to occur. This is new in human history and as the demand for water continues to increase, membranes will be able to offset the rise in consumption. VSEP membranes will uniquely be able to recover water from very challenging effluents.

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**VSEP is a Membrane Crystallizer**

Polymer Membrane Filtration is often used for water treatment. During the filtration process, very clean water is obtained as the permeable membrane allows very small nuclei to diffuse through it when pressure is applied. Suspended colloids, inorganic salts, dissolved organics, and other disassociated species are rejected. fouling can occur in several ways including charge association, hydrogen bonding, hydrophobic interaction, or from exothermic chemical precipitation of sparingly soluble earth metal salts which can occur at the membrane surface forming an attached crust.

Polymer chemists are developing many new membranes that have "low fouling" characteristics. Several techniques are used like altering the Zeta Potential or amount of ionic charge of the membrane surface. Another method is modifying the thermodynamic potential of the membrane surface by using low surface energy materials that reduce the chemical free energy change upon absorption of foulants.

"For every action, there must be an equal and opposite reaction" In stoichiometric chemistry calculations, it is assumed that the reaction runs to completion. In actual fact, a chemical reaction is a continuous state of equilibrium. A reaction may "look" finished when equilibrium is reached, but what is happening is that forward and reverse reactions are occurring simultaneously. Such is the case for partially soluble solutes in a solvent. Le Chatelier's Principle states that if a system at equilibrium changes, the system will shift its equilibrium to compensate for the change.

VSEP employs torsional oscillation at a rate of 50 Hz of the membrane to inhibit diffusion polarization of soluble and suspended colloids. This is a very effective method of colloid repulsion as sinusoidal shear waves from the membrane surface help to repel oncoming particles. The result is that

**Precipitated Gypsum without Membrane Scaling**

suspended solids are held in suspension hovering above the membrane as a parallel layer where they can be washed away by tangential crossflow. In the VSEP membrane system, precipitation will occur in the bulk liquid and become just another suspended colloid.

One other significant advantage is that the vibration and oscillation of the membrane surface itself inhibits crystal formation. Just as a stirred pot won't boil, lateral displacement of the membrane helps to lower the available surface energy for nucleation. Free energy is available at perturbations and non-uniform features of liquid/solid interfaces. With the movement of the membrane back and forth at a speed of 50 times per second, any valleys, peaks, or ridges become more uniform and less prominent. The smoother and more uniform a surface, the less free energy is available for crystallization. In actual fact, what happens is that nucleation occurs first at other nucleation sites which present much more favorable conditions. In this way, a VSEP membrane system acts like a conventional thermal crystallizer, but with much less energy use.

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**Expedited Mining Permits in the US**

On March 25th of 2025, the US government issued an Executive Order (EO) intended to stimulate domestic production of critical minerals and metals. The EO states that defense equipment, next generation technologies, electric vehicles and many other emerging technologies will rely on a secure, reliable, and affordable supply of critical minerals and metals. National and economic security are threatened by our reliance on mineral supplies from hostile foreign governments. In addition, human rights violations and environmental damage are common in mining in many countries that supply these materials. For example, child labor is used in the Congo for Cobalt production. The permitting quagmire has gotten so bloated, it can take decades to get final approval, even if you are able to. The EO streamlines the process and directs agencies to establish a "transparency list" of projects that have submitted applications for permits and are shovel ready.

This transparency list generated includes the NorthMet Project at an abandoned mine near Duluth Minnesota. A company called Polymet purchased the mine site nearly 20 years ago and began clean-up of the existing facility which was left idle. They began the process of applying for permits and spent $100M on environmental impact studies to support their permitting efforts. After two decades of permit review, the company acquired significant cornerstone financing from Glencore to keep the process going. Two years ago, Polymet and Glencore concluded a merger with Teck Resources combining two large copper-nickel deposits. The combined company is called NewRange Copper Nickel. Now that this project has been listed by the US government as a shovel ready high priority project, NewRange has announced that it will be submitting an updated permit application to the

Army Corps of Engineers. The company holds 21 of the 24 permits needed to begin operation

The company also conducted onsite pilot testing of wastewater treatment equipment including VSEP technology. This mine site is home to one of the largest undeveloped copper and nickel deposits. During the proposed mining operations, sulfur would end up in effluent because of the high Sulfur content of the ore and the use of Sulfuric Acid during leaching. When Sulfur or Sulfate enters surface waters, it can lead to acidification of the water and to the production of Hydrogen Sulfide (H2S) which is the chemical known for the rotten egg smell.

Environmental companies have fought against this project since the beginning. The concern is Sulfur releases to surface waters where wild rice grows, and which local Native Americans rely on for food. High Sulfur levels can also affect aquatic life and can be harmful to the environment. To remedy any of these concerns, the company demonstrated the VSEP technology and how it can treat the effluent to remove sulfur and provide water for discharge that is cleaner than the water body receiving it. The company showed that the VSEP treated water would remove 1500 tons of Sulfur per year and would meet the state's wild rice standards.

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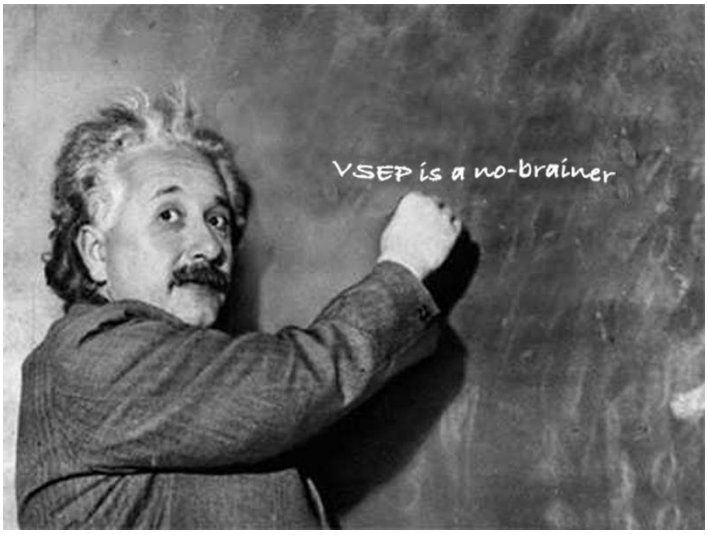
**VSEP Solves the Membrane Reject Problem**

Membranes are liquid/solid separation devices. Membrane systems can only filter liquids and cannot make dry solids. So, there is always a brine concentrate that is left. Because it has concentrated salt and other impurities, disposal of this is problematic. This often would mean evaporating large volumes of water. Conventional membranes like spiral wound membranes have many limits for suspended solids, solubilities of sparingly soluble salts, and organic materials. Typically, a spiral membrane system can recover 75-85% of the filtered volume as clean water filtrate or permeate. Then, what do you do with the 15-25% of the volume that remains?




People have devised all sorts of ways of increasing the recovery rates. Often pH adjustment and Antiscalant addition can delay precipitation and scaling and can boost the recovery slightly. Other times, lots of pre-treatment is used to remove hardness with softeners or to remove suspended solids with an Ultrafiltration step. Biological materials may require a biological digester ahead of the membrane which is the case for MBR systems. The conventional spiral membrane system relies on laminar crossflow to disrupt concentration polarization and to limit fouling and scaling. This requires high liquid velocity and pump energy. The filtered liquid passes through many spiral membrane elements in series and is designed so that when the final concentrate comes out the end, the optimum recovery is achieved.

There are some variants on this model. One is called a disc/tube (DT) membrane like the one made by Rochem. With this design membrane discs are stacked up in tubes and the flow path creates high turbulence to create more shear than the conventional. Another variant is the "Hero" system with stands for high efficiency RO. This system design is just a conventional spiral but with a very elaborate pre-treatment package to remove hardness, organics, and CO3 as a gas in different steps. Another system is known as CCRO which stands for closed circuit RO. This is the same as a conventional spiral system, except that the path through the membranes is shorter and the concentrate is recirculated back to the front. Periodically, concentrate is purged from the system. The idea is that the short path limits the time in the membrane elements and allows for some exceedance in solubility due to the time for crystallization.

VSEP does not have any of these limitations and can precipitate solids in the filter while filtration is occurring. Any other membrane system will have limits and will have large volumes of concentrate left to deal with. New Logic has installed many systems with VSEP to reduce the volume of the reject from a spiral. This includes taking the reject from a DT system, a Hero system, and a CCRO system. We installed a VSEP RO system at a car manufacturer who is using a CCRO system to filter cooling tower blowdown. The VSEP system installed several months ago is recovering 90% as permeate from the CCRO reject. Nothing else can come close to the brine reduction of VSEP.

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**Regulation Quagmire**

The administration of environmental laws and regulations is divided between numerous federal and state agencies. The Environmental Protection Agency (EPA) operates within the limits of federal jurisdiction and writes regulations to comply with the Clean Water Act which is limited to the waters of the United States. The US Fish and Wildlife Service and the National Park Service also act within the federal jurisdiction on environmental issues related to conservation measures. The Army Corp of Engineers regulates projects that may affect the environment. Some federal agencies delegate authority to state and local agencies for certain issues but maintain ultimate authority. The federal agencies also allow states to make regulations that are more strict than the federal rules. Navigating the maze of agencies involved in getting a permit to operate can be daunting.

New Logic has worked for several mining companies who are trying to get started and are going through environmental impact reports and then getting all of the necessary permits. One of these is a copper mine in Northern Minnesota. After 10 years and $100M is costs for EIRs and studies, they finally got all the necessary permits from state agencies and from the Army Corp of Engineers. They were released to begin operations. Then, the EPA asserted its option to review the permits given their ultimate authority. Most operations like this one would be handled by state and local officials. Since the EPA got involved, the project has been stopped for four years.

The US government recognized American Indian tribes as independent nations with the authority to govern themselves. The Civil War forged the US into a more centralized and nationalistic country departing much from the 10th amendment and states' rights. This also led to an assault on tribal culture and institutions. The Indian Appropriations Act of 1871 prohibited any future treaties. Currently, the US recognizes tribal nations as "dependent nations" and uses its own legal system to define the relationships. Courts have found that the US government has a duty to protect these dependent nations and therefore use its executive authority to administer.

**Klamath River in Northern California**

On July 30th, the EPA granted the Yurok Tribe in Northern California the authority to develop its own water quality standards, similar to authority granted to states in some areas. The EPA has a recent goal of Indian Self Determination and self-governance. This will primarily apply to the lower Klamath River located in the tribal lands. The authority includes the tribes in the region including the Hoopa Valley Tribe, Karuk Tribe, Pulikla Tribe, and the Quartz Valley Indian Reservation. The Yurok Tribe joins 32 other tribes in the Southwest US with this authority. The Yurok Tribe originally lived in an area of 500,000 acres and are now confined to an area of 90,000 acres located in Del Norte and Humboldt Counties in far Northwestern California.

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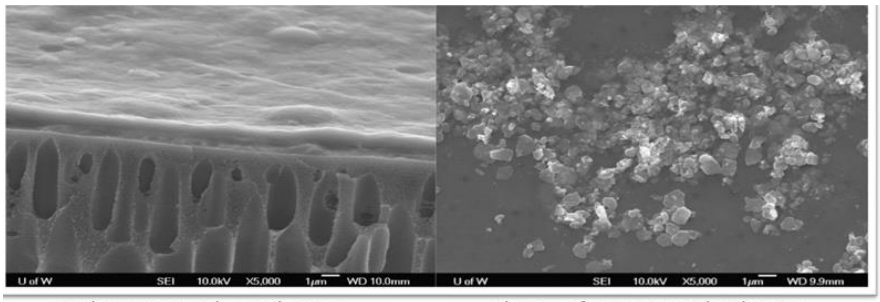
**Solution Mining**



Foulant Crust with no vibration

Clumps of Deposits with Vibration

When people think of mining, they often think of large open pits where massive amounts of earth are removed. Or they think of underground shafts where hard rock ore is extracted. But there is one method of mining that is not widely known. It is known as solution mining or in-situ leach mining. Many times, hard rock ores are not used. Some Lithium deposits are also found in mud. Both involve massive earth moving. But there are many metals and minerals that can be found in brine or can be leached using acid.

For the leaching process, a borehole is drilled into the metal deposit such as is the case with copper or uranium. Often explosives or hydraulic fracturing is used to make the deposit porous. Then an acidic solution, sometimes with an oxidizer, is pumped into the borehole. A second borehole is used to extract the pregnant solution where the liquid is processed to recover the metal. About 45% of all Uranium is mined using this method. The Chinese were mining for coper using this method as early as 177 BC.

Another example of solution mining is the extraction of Lithium from brackish groundwater. The water may contain 200 mg/L of Lithium and is pumped to the surface where it is transferred to a series of evaporation ponds. Because the dissolved solids have different solubility limits and will precipitate at different times, the brine cascades through the evaporation pond system until the most soluble Lithium is left for the final pond,

There are also some unique concepts when it comes to extracting metals and minerals. Of course, we have all heard about the amount of gold in the ocean, but it is not so easy to get. Another cutting-edge idea is to sequentially extract minerals from desalination brine, especially inland brine. Because you have extracted the brackish water and have removed much of the volume for use as drinking water, the reject will be concentrated in minerals that can be recovered and sold such as gypsum and magnesium hydroxide.

Because VSEP does not have solubility limits and because a membrane can be selected for a specific separation, it can be used for this kind of work. We have tested the Lithium brine option where we can remove magnesium and calcium and allow clean Lithium water to pass through a Nanofiltration membrane. We have also tested an inland desalination plant reject for the recovery of gypsum and magnesium hydroxide. Both of these were separated from the brine. In the case of magnesium hydroxide, it was insoluble and was removed with Ultrafiltration. In the case of Gypsum, the brine was super saturated with Calcium Sulfate and VSEP was used as a membrane crystallizer to precipitate and recover the gypsum product.

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**Water is Complicated**

This is not a water treatment or a VSEP article, but for people in the business, it is an interesting story about water. Water can be a complete mystery sometimes. New Logic is in the water treatment business, and we are constantly trying to understand water and how it behaves. Even pure water is not as simple as you might think. For mental exercise, physicists have wondered about the formation of the planet and how the water we have come to be. You have heard stories about how we are always searching for water on other planets because if we were to settle there someday, water is needed to sustain life. So, some have theorized that water was not present on our planet at the beginning and arrived later. Bear with me.

One theory is that comets delivered water through massive impacts. Some Halley-type comets carry water. Nasa astrophysicists are able to use very powerful telescopes including the Atacama telescope in Chile and the IRTF telescope in Hawaii to measure the chemical footprint of comets. Specifically, they can look at Hydrogen. There are two forms of hydrogen. The most common type had one proton but does not have a neutron. This is what exists in normal H2O. There is another isotope of Hydrogen called Deuterium where the hydrogen molecule contains a Neutron. This is known as heavy hydrogen and is found in heavy water. All of the deuterium that exists was created billions of years ago in the big bang. Since there is a fixed amount of hydrogen on our planet. There is a specific ratio of deuterium to regular hydrogen. The ratio in the ocean is 156 Deuterium nuclei for every 10 million hydrogen nuclei. This is like a fingerprint, and the ratio is fixed. Gas planets that contain water have a lower ratio. This D/H ratio has been measured on some of the Halley-type comets.

Most comets have different D/H ratios. However, recently scientists discovered that comet 12P/Pons-Brooks has a D/H ratio that is almost identical to

earth's water. Until now, it was hard to prove that water came from comets. But with this comet also known as the Devil Comet, the case for water delivery could be supported. These Halley-type comets orbit the sun every 20-200 years and are considered leftovers from the early solar system. How many of these once existed and then collided with planets is not known. The Devil Comet is the size of Mount Everest and can contain large amounts of water. The Devil Comet was visible last spring after its 71 year orbit around the sun. It is referred to as the Devil Comet because of its unusual tail of gas.


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