Sub-Surface Demand Driven Irrigation of Redwood and Other Tree Species With Wastewater

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To: City Council of Santa Rosa

Re: EIR review of **Santa Rosa Subregional System Longterm Wastewater Treatment Options**

The city of Santa Rosa has expended several million dollars during the last decade on technical reports and an EIR prepared by a series of engineering consulting firms. Great attention has been paid to the use of treated wastewater for agricultural crop irrigation. While there is general agreement by the public that such irrigation is desirable the particular method of crop irrigation currently used by the city suffers from significant limitations which in fact are the primary reason that this entire exercise in consultation is necessary. 001

Santa Rosa is currently able to disperse through a high pressure, surface sprinkler system which irrigates grassland, all of the wastewater generated by the sub-regional WWTP during a substantial portion of the year. The 5,000-6,000 acres currently under irrigation are sufficient to move all of the approximate 20 MGD generated by the plant during that time.

Unfortunately surface irrigation of grassland is limited by several physical and biological factors which make it a poor method for wastewater dispersal. These include, but are not limited to the following:

1. Low rate of application - Even at the height of the summer dry season (June/July/August) only an average of 4,200 gallons/acre/day can be applied without causing erosion and runoff.

2. Public Access Restrictions - Surface systems expose the public directly to wastewater, not just at the site but off-site as well, through wind blown aerosols and surface runoff to local watersheds. This forces the need for advanced treatment and chemical disinfection and limits the available sites.

3. Physical Site Restrictions - Passive diffusion is the primary force driving the movement of water into the soils being irrigated. This is a slow process and can only occur in very specific soil types. Soil must be relatively flat to avoid runoff and erosion. Soil must be

porous so diffusion can occur while at the same time it must be homogeneous to prevent leaching through channels to ground water reservoirs. Because of this only a very limited set of soils are appropriate and coincidentally these particular soils tend to be the highest value land thus the highest potential cost to the system. 001 (cont.)

4. Vector Control - Surface irrigation as typically conducted results in pooling of water at the site. These pools create substantial habitat for the breeding and dispersal of mosquitoes. This presents a direct threat to public health as it is well known that mosquitoes transmit a number of dangerous pathogens.

5. Pollution Problems - Surface irrigation is a "supply driven" system in which water is forced on the plants being irrigated. The theoretical maximum efficiency of such irrigation is only about 70-80% with 20-30% of the water not taken up by the plants, and when operated under the constraints faced by the city this theoretical maximum is rarely even approached. As a consequence, many of the nutrients, salts, and metals contained in the wastewater are not taken up by the plants but instead are leached out of the soils when winter rains wash them into the subsurface aquifers and into the local watersheds.

6. Cost - Even when working correctly this type of irrigation is excessively expensive. High pressure pumps utilizing large quantities of electricity are needed to project the water far enough to cover any substantial area. Expensive high-pressure aluminum pipe with very short life spans are needed to circulate the pressurized water. Large numbers of sensitive moving parts are inherent to the system involving a tremendous investment in man-hours for maintenance of the system. Constant negotiations with the farmers that receive the water are necessary to assure the appropriate irrigation rates.

7. Low crop production and value - Grass crops for hay or green sileage have just about the lowest per acre tonnage of any agricultural crop. Hay is a poor crop because irrigation must cease during the drying period. Green sileage has a limited local market which is decreasing. Both crops command a very low price per ton and are given away by the city in any event.

8. Seasonal Limitation - Again, surface irrigation is a "supply driven" force feed system. Soil becomes saturated at the surface receiving the applied water and can only absorb more water as the earlier water moves away through passive diffusion, a very slow process. Evaporation is limited by the fact that the evaporative surface is receiving a continuing supply of new water, and transpiration by grasses, limited in any event, occurs in the saturated zone and near the soil interface where boundary layer effects minimize air movement. Grass blades, being restricted to a very flat surface, contain a very low overall evaporative surface for transpiration to occur because it is essentially two-dimensional. All of the above conditions are exacerbated during the winter rain period. Continued saturation of the surface by rainfall effectively eliminates any transpiration or diffusion potential in the soils so surface irrigation is completely ineffective during this period.

It is this final limitation, <u>THE INABILITY TO IRRIGATE DURING THE WINTER WET-WEATHER SEASON</u>, that is the single factor upon which the entire EIR process with its varied solutions and expensive consultation is predicated. 001 (cont.)

It is ironic that the years in which Santa Rosa violates it river discharge permit are not the high rainfall years. No matter how little rain falls enough will occur to saturate the soil and destroy the potential for the current ineffective system to continue irrigation. During such years Santa Rosa cannot abide by the 1,000 CFS river flow limit or the 1% of river flow cap on discharge so they are forced to seek waivers or violate their permit.

Every single project identified as a solution to the current dilemma is predicated on the presumption that winter irrigation is not possible. This being the case it is clear that the logical first step in a competently designed analysis would be to test this central assumption. This could have easily been done by checking alternative methods of irrigation. Unfortunately there is little evidence that the abundantly compensated consultants made any attempt to do so.

Instead this task has been assumed by unpaid local residents, who fortunately possess the expertise not in evidence on the staffs of the paid consultants, and who are willing to do sc as a public service to their community. Make no mistake, we are deeply angered by the profligate waste of county and city taxpayer dollars collected by the paid consultants. These feelings, however, will not move the city of Santa Rosa further.

Irrigation Options

Surface irrigation can be conducted in a number of ways but virtually all such systems, be they overland flow, surface drip, flood irrigation, surface irrigation of forests, suffer from the same limitations faced by the current ineffective system used by the city of Santa Rosa.

Subsurface dispersal options exist but the most widely known methods also have limitations. Leach fields are effective but are highly site specific and limited to a narrow range of soil types and slopes. Like surface irrigation of grassland, leach fields depend on passive diffusion so rates of uptake by the soil are low and vast acreage would be necessary to move the large volumes of water generated by the Santa Rosa system.

Aquifer injection is a temporary subsurface disposal method but it suffers from very important limitations involving the biochemistry of wastewater. Oxidized compounds in the wastewater stream such as nitrate and sulfate will undergo reducing conditions when injected below ground at depth. Such conditions will lead to the formation of very toxic by-products such as hydrogen sulfide and nitrite. These have the potential to contaminate vast underground water stores while making the stored water highly undesirable for later use as irrigation water.

One method of subsurface dispersal does exist, however, that takes advantage of the enormous transpiration potential of trees, especially those like the locally occurring Redwood species, *Sequoia sempervirens*.

It is widely known that planting trees near a standard leach field will greatly stimulate the tree growth through the added nutrients, but most importantly through the increased water availability. Unfortunately standard leach pipe will be readily clogged by the tree roots so trees must be located a minimum distance of 50 feet from standard leach systems. 001 (cont.)

Subsurface dispersal systems are commercially available, however, which are specifically designed to be impervious to clogging of the system, while at the same time they allow thorough envelopment by tree roots. These systems can be configured so that water passing through the units will not be dispersed to the external soil milieu except through active transport by the tree roots. They are thus, "demand driven" systems instead of the "supply driven" system currently used by the city.

The power of this transpiration potential can be understood when one considers that a single mature redwood tree will transpire 500 gallons of water in one day. This means that as few as nine mature redwood trees will consume as much water as one acre of grassland. Other species of trees can be equally effective. The much date tree, even though much smaller than a redwood, can move up to 125 gallons per day. A plantation of redwoods planted at the easily supportable density of 200 trees per acre could result in the staggering transpiration potential of 100,000 gallons/acre/day, fully **2,000%** higher than the top rate achievable by Santa Rosa's current system.

The Sonoma County Board of Supervisors acting as the Water Agency Board are at this time involved in an EIR review similar to that facing the city. In public hearings they were apprised of the technology for subsurface transpiration irrigation for the purpose of growing tree crops. The Water Agency Board directed staff to include a thorough study of subsurface technology in their own EIR in order to assure that the study would be legally defensible, as well as to seriously consider the advantages in aspects such as cost, environmental health, and public safety in the communities in the west county.

The opportunities presented to the Santa Rosa system by a well designed subsurface forest transpiration system can be best expressed in the context of the previous list of limitations to surface irrigation of pasture.

1. Rate of Application - A first generation subsurface transpiration forest at the Mountain View district WWTP in Martinez, California documented a rate of application that was in excess of 6 times higher than that achieved by Santa Rosa using surface irrigation of pasture. Over 27,000 gallons of secondary wastewater (not expensive tertiary) was dispersed per acre and that rate was limited by the lack of sufficient water to drive the system to a true maximum which would be higher still.

2. Seasonal Limitation - Subsurface transpiration is a "demand driven" method powered by active removal of water from the system through tree-leaf transpiration. Passive diffusion, typified by the supply-driven Santa Rosa system, is replaced by a living capillary network capable of moving water over a wide area and as high as 300 feet into the air in the case of Redwood trees, **without any energy input at all.** Evaporation from the soil

plays no role in the system so seasonal limitations are minimized. The leaf surface area dedicated to transpiration is three dimensional because it projects into the volume of air space above the soil surface increasing transpiration area by orders of magnitude over two dimensional pasture. More important, while grass cannot transpire in winter because it is in a saturated environment with little air movement, the leaves of trees are elevated into the area of highest wind and transpire significant quantities of water throughout the year. **The transpiration forest at Martinez moved an extra 67% more water in February during the rainiest and coldest month of the year ~ 7,000 gallons/acre/day ~ than the irrigation rate for the Santa Rosa system during the June/July/August height of the city's irrigation season.** 001 (cont.)

This feature cannot be stressed enough. Every single aspect of the conclusions reached by the current EIR are predicated on the insupportable assumption that irrigation is impossible during the winter rain season. The data from Martinez unequivocally show that this is not the case.

Again the Martinez demonstration project was a first generation attempt at subsurface dispersal of wastewater. The trees used in the project were only a few years old and no attempt was made to dense-pack the forest. Several aspects of this technology can be optimized further and a carefully crafted project could allow Santa Rosa to stay within their current waste discharge permit requirements and still provide sufficient opportunity to increase capacity as growth in the community required it.

A subsurface transpiration forest located in a place such as the Petaluma Wind Gap, where rainfall is low and winds are high, could move more water per acre at the height of winter than any current pasture being irrigated by the city at the height of summer. The seasonal timing is ideal because the data at Martinez showed that some of the highest transpiration levels of the year were in March and April due to the high winds and in spite of the rain. This is typically the period when in dry years the city has filled its storage but because of low river flow cannot discharge its water or conduct surface pasture irrigation. In the low rainfall years that are currently the city's problem one would see the highest possible dispersal rates for wastewater through a subsurface transpiration forest.

3. Public Access - Subsurface irrigation eliminates all public contact. Wastewater suitable for such disposal needs only secondary treatment, and in fact can be designed for primary effluent. This greatly reduces treatment costs, and in actual fact the system will work better with limited treatment because the trees are stimulated to maximum growth by the nutrients that are currently considered a problem in the Santa Rosa system. Costly ultraviolet or environmentally hazardous chemical disinfection is unnecessary in a Subsurface Transpiration Forest. Monitoring costs for such waters borne by the WWTP are reduced to simple measurements of suspended solids instead of the complex analyses necessitated currently.

4. Site Restrictions - The definition of agricultural crop in the EIR arbitrarily and wrongly omits forest products. This is a particularly egregious error given the importance

of forest products to the Sonoma County economy. The county facility at Guerneville has long irrigated redwoods on Louisiana-Pacific property and Louisiana-Pacific gave approval and encouragement to a proposed subsurface transpiration project in the upper sloped highlands of that same property. When "agricultural crop" is expanded to include tree products virtually every single site identified by the EIR, as well as many other sites that were disqualified, will work for a Subsurface Transpiration Forest. 001 (cont.)

In actual fact many more sites, including steep slopes or heavy clay soils could be added to the irrigation sites, and in some instances would actually be desirable. It is widely known that establishing a forest on a steep slope is the simplest and most effective way to stabilize such a site. The devices currently used in subsurface transpiration systems are place in trenches of varying size and configuration. As long as the contents of such trenches are filled with permeable soil, which is an obvious and inexpensive component of their design, the system can be located at a site that is completely impervious. The tree roots will still permeate the trenches and transpire the water. Unlike surface irrigation, the transpiration system is not a supply-driven leach system.

5. Vector Attraction - No mosquito habitat can be created with this system.

6. Pollution Problems - Unlike surface pasture irrigation, which is substantially a leachate method, subsurface transpiration units can be configured so that no water is released from the unit except for that which is actively transpired by the tree roots associated with the system. No salt residues are left by evaporation. Nitrates will not leach into the water table, and in fact nitrates being released by the WWTP become an important asset as fertilizer for the trees. Currently nitrates are considered a public health hazard and the city is facing the proposition of implementing a $40 million denitrification system at the plant.

The Santa Rosa system currently needs irrigation of dairy for the perverse reason that it masks the nitrate contamination present in the tertiary water. Application on land that is already highly nitrified makes the minimal, but measurable, nitrates in the wastewater less obvious. It also means that these high value fertilizer compounds are being thrown away because the plants at the site are already saturated with them. Those tons of nitrates the city throws away ultimately reach the ground water and the surrounding water courses and represent an environmental and public health hazard. A subsurface system which utilized those nitrates to grow trees relieves the city from the inherent hypocrisy of the current dispersal method, capture their high value and prevent migration into natural waters.

7. Cost - The prime driving force of water through the dispersal component of a subsurface transpiration forest is the solar energy that drives tree growth and transpiration The only active pumping needs are met with low pressure pumps moving water to and through the system. The system is constructed with inexpensive plastic piping and is set in shallow trenches that can be dug with a hand operated "Ditch Witch" trencher. There are virtually no moving parts to wear out and the systems currently in operation are uncloggable with a proven track record of decades. At the Martinez plant the

transpiration forest was automated and completely maintained with only an occasional visit by the operator. Sometimes literally months without attention would pass with no detriment to the system. All of the above coupled with the enormous reduction in land needs make a Subsurface Transpiration Forest cost as little as 5-10% of an equivalent surface pasture irrigation system. 001 (cont.)

This cost feature added to the fact that economies of scale are not a factor in a transpiration forest allow this system to be implemented in an incremental fashion. The incredible fact about a transpiration forest is that it gets increased capacity automatically as the trees grow. New capacity is the inevitable result of biology. This results in a system that is completely growth neutral. The large infrastructure cost of a system sized to serve an estimated larger future population, which then necessitates an immediate grow-out simply to pay for the system, is completely avoided.

8. High production and high value of product - A mature redwood forest in northern California was estimated to contain **170,000 tons** of biomass/acre. This is the highest standing stock of biomass in any ecosystem on earth including such notoriously high production ecosystems as salt marshes or tropical rain forest. A good grape crop is 5 tons and achieving more than a couple tons of hay per acre is an achievement.

More significant however is the value of redwood and other forest crops. A redwood tree will grow to 150 feet at a diameter of 6 feet at the base in 60 years without irrigation or fertilization. One such tree will contain 50,000 board feet of timber. If the city of Santa Rosa were to plant 800 acres of redwoods at the easily supported density of 200 trees per acre those trees would yield **8 BILLION** board feet of lumber in 60 years. This is a gross underestimate because it does not factor in the enormous increase in growth rate that would occur with abundant water and fertilizer provided by the wastewater.

The current market value for second growth redwood is $1.00 per board feet. At current prices the market yield would be **$8 BILLION,** or **$130,000,000** per year over the 60 year period. Each acre of such a transpiration forest would produce **$162,000** per year for the city of Santa Rosa. An it should be noted that inflation of redwood prices is certain to rise much more rapidly than the overall rate of inflation.

In view of the staggering profitability of forest products it is obvious why private companies like Louisiana-Pacific are willing to tie up capital for periods of several generations. They are well rewarded, indeed.

The city of Santa Rosa faces the need to issue bonds in the amount or tens of millions of dollars to finance their expansion. If such bond income were used to plant a transpiration forest of redwoods, the value of the forest product alone would be the strongest possible backing for the bonds relieving any and all taxpayer burden.