The Davis-Woodland Water Supply Project (DWWSP) concept is well-established. It has an adopted EIR, implementing Agency (the Woodland-Davis Clean Water Agency) and staffing that includes a general manager, complete with legal counsel and consultants, and expects to secure a water right permit soon. Furthermore, the Agency recently released a request for qualifications to solicit submittals of qualifications for teams interested in designing, constructing, and operating the regional facilities. Amidst a great deal of forward momentum, many people are still asking the question: "are there alternatives to the DWWSP?". In short, the answer is "yes", but practically speaking, the answer is "no". Several potential alternatives have been considered as described below.

A summary listing of all 27 DWWSP alternatives identified in various studies and reports over the past twenty years is provided in Tables 1 through 4, included in this technical memorandum and also available at:


Table 1 lists alternatives specific to just Davis and UC Davis; Table 2 lists alternatives specific to Woodland; Table 3 lists joint Davis-Woodland alternatives to the DWWSP; and Table 4 includes the alternatives to just siting the intake portion of the DWWSP.

Tables 1 through 4 include a column to indicate whether the studied alternative meets the DWWSP objectives. The three objectives of the DWWSP identified in the EIR include:

- Improve drinking water quality
- Improve water supply reliability
- Improve quality of wastewater discharge
For an alternative to be viable, it would have to meet these three objectives. Therefore, an option such as “conservation only” (alternative 1H from Table 1, 2G from Table 2, and 3I from Table 3) does not qualify as a viable alternative to the DWWSP because it would not improve drinking water quality or wastewater discharge quality. (Note: A very aggressive water conservation program has been built into demand projections for the DWWSP). Out of the 27 alternatives studied, only 14 meet the DWWSP objectives. Of these 14, five involve the use of the City of West Sacramento’s treated surface water. However, the City of West Sacramento determined in the late 1990s that they were not interested in participating in a water project with Davis or Woodland. An additional four of the alternatives that meet DWWSP objectives are just variations of the proposed DWWSP (e.g. use Ranney Collectors instead of the proposed surface water intake; use of Tehama-Colusa Canal water; include a summer supply storage reservoir; and implement the project for just Davis/UCD). Some of these water supply alternatives (including the Ranney Collectors, Tehama Colusa Canal, and two others) are described, and ruled out as viable alternatives, in further detail below. The remaining five listed alternatives that meet DWWSP objectives are variations of the concept of treating groundwater to improve water quality. To treat the groundwater to a high enough quality such that wastewater discharge regulations could be met, reverse osmosis treatment would be required. All five groundwater treatment alternatives include reverse osmosis treatment. These alternatives just vary by the location of treatment and location and method of brine disposal.

SURFACE WATER SUPPLY ALTERNATIVES

The surface water supply alternatives that could potentially meet DWWSP objectives include: 1) Ranney Collectors (alternative 4E of Table 4); 2) Tehama Colusa Canal water (alternative 4D of Table 4); and two alternatives that were not listed in Tables 1 through 4. These other concepts include: 3) using surface water from Lake Berryessa or Putah Creek; and 4) receiving surface water from the Yolo County Flood Control & Water Conservation District (District). Three of these water supply alternatives are not viable due to prohibitive costs, schedule delays, high risks, and/or physical infeasibility. The option of working with the District on a county conjunctive use project is still under consideration.

Ranney Collectors

Ranney Collectors were studied in detail in early 2010 to solely serve the DWWSP in place of an in-river intake. Ranney Collectors are a patented alternative to conventional vertical wells and are generally comprised of a vertical reinforced concrete shaft (or caisson) with horizontal lateral well screens projected out into the aquifer to collect surface water-influenced groundwater. Although the exact number, size and placement of Ranney Collectors required for this alternative was not determined, it was estimated that approximately 6-10 Ranney Collectors would be required along the western bank of the Sacramento River, in the area between (and likely extending beyond) the existing RD 2035 intake (just north of the I-5 Vietnam Veteran’s Memorial bridge) and the Plan B intake property (about a half mile upstream of the RD 2035 intake).

To help develop a sense of the feasibility of Ranney Collectors for the Agency, Wittman Hydro Planning Associates (WHPA), an affiliate of Ranney Collector Wells, constructed and analyzed a simple hydraulic model for hypothetical collector wells in the vicinity of the Plan B intake site. Results of WHPA’s hydraulic model indicate a range of collector well yields from 2.2 to 10.4 MGD per collector.
If all of the water from a given collector well were surface water, a well yield of 8-10 MGD would require 6-7 collectors to meet the Agency’s needs. If only 70 percent of the water from a given collector is surface water and 30 percent is groundwater, it might not be possible to meet waste discharge requirements for treated wastewater. Also, groundwater captured by the Ranney collectors could result in customer dissatisfaction related to water quality concerns.

Based on the estimated number of collectors required for the DWWSP, costs for this alternative would be substantially higher than those for other alternatives. Further, it is not clear that the area between the Plan B parcel and the existing RD 2035 intake is large enough to contain the collectors. It is possible that additional property along the western bank of the Sacramento River would need to be acquired by the Agency to accommodate the number of collectors required.

It is estimated that $300,000 to $400,000 would be necessary to complete the more detailed field investigations required to adjust the assumptions made by WHPA and confirm the feasibility of using Ranney Collectors for the DWWSP.

Trussell Technologies evaluated the water quality treatment implications of using Ranney Collectors for the DWWSP. They found that Ranney Collectors instead of a traditional screened river intake offers some apparent advantages including: turbidity, pathogen, and TOC removal; reduced sediment loads during periods of peak river flow; and protection against nuisance mollusk infestations and minimal disturbance of aquatic habitat. However, there are some significant unknowns associated with Ranney Collectors which present serious disadvantages. The major disadvantages are: (1) the raw water quality is unknown and has the potential to provide a water with a higher mineral concentration (as measured by TDS) than in the river; and (2) the system does not lend itself to pilot testing of a preferred process train.

For the river intake alternative, a conventional treatment train using oxidation, coagulation, flocculation, sedimentation and filtration (granular media or MF) would be effective. Alternatively, high-rate clarification (e.g., sludge blanket clarification, ballasted sedimentation (Actiflo®), etc.) and filtration could be used, which would reduce the treatment plant footprint. Either of these would also be effective for TOC and iron/manganese removal.

While the raw water quality from a Ranney Collector is unknown, there is a great likelihood that treatment for iron and manganese will be required. It is also probable the water will be classified as Groundwater Under the Direct Influence (GWUDI) and subject to the treatment requirements of the Surface Water Treatment Rule (SWTR) and Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). Treatment could include oxidation (for iron/manganese) followed by coagulation, flocculation, and direct filtration through a granular media filter. This process train would be appropriate for particulate removal as well as NOM and colloidal iron/manganese removal. It is possible that direct filtration through a MF membrane—using coagulation and flocculation to reduce colloidal material—would be viable, but careful consideration should be given to the choice of preoxidant and reaction time provided. Alternatively, a greensand type media (e.g., natural greensand or KMnO4 pretreated silica sand and/or anthracite) could be used for filtration, which is known to be effective for manganese removal. Because of the risk of membrane fouling due to incomplete oxidation of the manganese and/or the presence of colloidal iron/manganese, membrane filtration alone—without preoxidation and coagulation—would not likely be recommended.
The primary “major” process difference between the treatment train recommended for a conventional river intake versus a Ranney Collector intake is that sedimentation would be necessary with the river intake but not with the Ranney Collectors. Direct filtration would be an option with Ranney Collectors, but would not be an option with the river intake because of the higher solids loading and variable turbidity of the river. Membrane filtration without coagulation would not be an option for either intake scenario. The downside of a Ranney Collector intake, though, is the number of associated unknowns and the associated risk of treatment related problems.

In summary, the uncertainties related to Ranney Collectors were that 1) the capacity of the Ranney Collectors is unknown; therefore the quantity required for the Project is unknown; 2) the raw water quality is unknown and has the potential to provide a water with a higher mineral concentration (as measured by TDS) than other Intake options. Furthermore, this alternative is risky because it 3) does not lend itself to pilot testing of a preferred process train at the water treatment facility. Therefore, costs for the alternative cannot be clearly defined. There are numerous unknowns with this alternative which would necessitate expensive and time-consuming field investigations to resolve. As a result, this alternative is not viable because it would delay the schedule and put the project at too much risk.

**Tehama Colusa Canal Water**

The Tehama-Colusa Canal (TCC) is an agricultural water supply facility that diverts water from the Sacramento River at Red Bluff. Currently the diversion is made by gravity, made possible by damming the Sacramento River by means of operable gates that form an on-stream shallow reservoir behind the dam when the gates are closed. A long history of fish passage problems with this dam have resulted in it being targeted for removal, with replacement of the gravity intake by a pumping plant and fish screen. Existing facilities are limited to use for four months of the year due to conflicts with threatened and endangered fish species, principally Chinook salmon. The TCC is 140 miles long and provides irrigation water to 150,000 acres of farmland in the Tehama-Colusa Canal Authority service area. An extension would need to be constructed to deliver water from the terminus of the TCC to the DWWSP water treatment facility.

The TCC as an intake and conveyance option is substantially more expensive – more than 2.5 times the capital cost of the proposed RD 2035 Sacramento River intake alternative. A more thorough evaluation of both options (including follow-up discussions with the U.S. Bureau of Reclamation and the Tehama-Colusa Canal Authority) would refine the costs, but a very large difference in costs would remain.

In addition, the uncertainties in water rights, municipal water delivery priority through agricultural conveyance facilities, and conveyance costs are matters that will require extensive negotiations and are likely to increase costs further and complicate and delay DWWSP implementation. There are also potential concerns about the impact of chemical aquatic weed control on source water quality for drinking water purposes. For these reasons, the TCC is not considered to be a viable alternative to the planned DWWSP diversion at a shared RD 2035 intake site.
Lake Berryessa or Putah Creek

Obtaining surface water from Lake Berryessa or Putah Creek is not listed in the alternatives tables because it was ruled out as an option back in the 1950s. More than sixty years ago, the City of Davis had an opportunity to participate in the Solano Project to secure a surface water supply, but chose not to pursue the opportunity. Now, all the water in the Solano Project is fully subscribed to water users in Solano and Yolo counties, excluding Davis and Woodland. UC Davis, however, does receive about 4,000 acre-feet per year from the Solano Project.

Yolo County Flood Control & Water Conservation District

The District, which encompasses much of Yolo County, including Woodland and Davis, has surface water rights for Clear Lake and Indian Valley Reservoir to supply its District customers. Although this water is likely of suitable quality for a drinking water treatment facility’s raw water supply, the District uses its water almost entirely for irrigation purposes. The District also has ample groundwater supplies which are mostly unused due to the abundance of its surface water resources. In concept, the District could use more groundwater for irrigation and deliver its excess surface water, through exchange, to the Agency. This concept involves taking advantage of storage in the region’s aquifer system to store additional supply during periods when excess surface water supply is available, then using this stored water when surface water supplies are limited. This conjunctive use alternative may be capable of yielding up to 20,000 acre-feet per year of summertime supply for the DWWSP. This quantity is not enough to replace the DWWSP, however, this conjunctive use is a real option for providing the DWWSP with a supplemental summer water supply.

Surface water delivery via the District could include: (1) an exchange involving the District and the Conaway Preservation Group (CPG), and/or (2) an exchange of Sacramento River discharge and diversion water. Both options would involve development by the District of a conjunctive use program to increase groundwater recharge within the District service area by recharging wintertime surface water from Cache Creek in the District’s canals. The District would recover this water by additional groundwater pumping during the irrigation season. Recharge would be accomplished through deep percolation of water from the District’s existing canals and, potentially, new recharge basins. Stored groundwater would be pumped for irrigation purposes within the District service area in the summer months, and exchanged for an equivalent amount of surface water that would otherwise have been released from available District storage in Clear Lake and Indian Valley Reservoir.

For the first option, the exchange would involve the release of surface water from the District’s Indian Valley Reservoir for delivery to CPG. Flows would be conveyed along Cache Creek or Willow Slough and diverted at CPG’s existing points of diversion. CPG’s reduced demand for Sacramento River water would allow increased summertime diversion, conveyance and treatment of Sacramento River water by the Agency.
The second option would involve the District discharging water to the Sacramento River at the Knight’s Landing Ridgecut via an extension of its West Adams canal, upstream of the DWWSP intake. The District would discharge surface water to the Sacramento River, and the Agency would pump an equivalent amount of Sacramento River surface water from its intake. A key advantage of this option is the potential to improve water quality in the Sacramento River at the Knight’s Landing Ridgecut location, which at times is impacted by discharges from the Colusa Basin Drain, the largest discharge of agricultural return flow to the Sacramento River. Diluting Colusa Basin Drain discharge upstream of the intake is a key advantage of this option, although the water downstream of the Ridgecut would experience a slightly increased salt loading than at present because the District surface water tends to have a higher salinity than the main stem of the Sacramento River.

Under both options groundwater would be pumped either by the District and distributed through the canal system, pumped by the District directly onto agricultural lands, or pumped by landowners within the District’s service area. Studies would be required to determine the technical feasibility, potential for sub-regional groundwater basin impacts including subsidence, water quality and impacts to the Sacramento River, and economic feasibility for the District to implement a conjunctive use program of the scope and scale that would be required to serve existing irrigation and future municipal needs.

In short, the conjunctive use options involving the District are variations of, rather than alternatives to, the proposed surface water supply system in the DWWSP. Work is currently underway to evaluate both options described above. The details of both options are being further defined, facilities and programs required to implement the options are being evaluated, as are potential groundwater impacts and institutional hurdles.

GROUNDWATER SUPPLY ALTERNATIVES

All five groundwater treatment alternatives include reverse osmosis treatment. Conceptually, reverse osmosis treatment can be conducted directly at the well sites (a.k.a. well-head treatment) or at centralized water treatment plants. Although theoretically more efficient, treatment at centralized water treatment plants was determined to be less feasible than well-head treatment due to the high cost of extensive piping infrastructure that would be required to connect the wells, water treatment plants and distribution system piping. Therefore, well-head reverse osmosis treatment is determined to be the only viable alternative to the proposed DWWSP.

WHY NOT PURSUE WELL-HEAD TREATMENT?

After screening the potential alternatives to well-head reverse osmosis treatment, the next obvious question is “why not pursue wellhead treatment?” Alternatives 3B, 3C, 3D, and 3E from Table 3 include well-head treatment. With well-head treatment, the drinking water quality is improved, and therefore the wastewater discharge quality would also substantially improve. Although treating the groundwater does not increase water supply quantity, it does make the existing groundwater supply more reliable because it provides a high quality water supply that could meet any future regulations.
One drawback to any form of well-head treatment is that it may be difficult to implement at some well sites due to physical site constraints. With regards to reverse osmosis, although the process provides excellent quality water, the drawbacks are abundant. To begin with, treatment of groundwater by reverse osmosis would require additional pumping. Furthermore, reverse osmosis treatment is the most expensive form of water treatment not only because of the large quantity of energy required to perform the treatment, but also because of the brine waste stream generated by the process (about 10 to 20 percent of the water supply would be converted to brine). The energy cost and associated “carbon footprint” are very significant and make this alternative undesirable. With the additional consideration of brine storage and discharge challenges, the EIR determined reverse osmosis to be an infeasible alternative to the proposed DWWSP.

The details of the drawbacks to well-head treatment in general and the specifics of reverse osmosis are summarized in the sections below.

**Well-site Constraints**

The City of Davis currently operates twenty groundwater wells to meet municipal demand, the City of Woodland operates eighteen wells, and the UC Davis campus operates six wells. Reverse osmosis facilities would need to be installed at all or most of these wells to meet current and anticipated drinking water and wastewater discharge limits. Individual-well reverse osmosis facilities would be installed on existing wells located in existing residential neighborhoods, and at sites with sufficient space. Additional power lines and other electric power facilities would also be needed to provide sufficient energy for operating the reverse osmosis and other appurtenant equipment.

Well-head treatment may be difficult to implement at some well sites due to physical site constraints. Many wells are located in developed commercial or established residential areas where site expansion is not an option. Furthermore, even if there is room for treatment, the noise and frequent, routine operations and maintenance employee site visits may present an inconvenience to residents and businesses at many of the well sites.

**Energy Costs and Associated “Carbon Footprint”**

Treatment of groundwater by reverse osmosis would require additional pumping. Approximately 10 to 20 percent of the volume of treated water would be removed as brine. To meet anticipated demand, this volume would have to be made up by additional groundwater pumping and reverse osmosis treatment. Reverse osmosis treatment is the most expensive form of water treatment not only because of the large quantity of energy required to perform the treatment and additional groundwater pumping, but also because of the energy required to store and dispose of the brine waste stream generated by the process. The substantial energy requirements associated with reverse osmosis create a significantly greater “carbon footprint” than the proposed DWWSP and are enough to make the alternative undesirable.
Brine Storage and Disposal Challenges

Storage

Brine storage and disposal from the reverse osmosis treatment process needs to be accommodated to implement this form of treatment. Storage tanks would need to be installed on concrete foundations and would need to be large enough to accommodate peak brine generation rates. Evaluation of construction challenges would be required on a site-by-site basis, but it is unlikely that well-head treatment at well locations with confined sites would be technically feasible because the areas surrounding many of the existing wells are heavily developed residential areas and there is insufficient space to add necessary facilities at these locations.

Each well-head reverse osmosis treatment facility would require routine collection, storage, and disposal of saline brine waste. Therefore, each well site would require access by tanker trucks at intervals to transport and dispose of about 10 to 15 percent of the well’s water production, the typical percentage of brine production at a reverse osmosis facility using current available treatment technology. It is estimated that, to meet the new discharge requirements, about 50 to 70 percent of untreated water would pass through the reverse osmosis treatment unit, and then be blended with the remaining untreated water. The exact percentage would depend on the salt concentrations of the water pumped from individual wells. If the entire water demand would be met by groundwater, about 26 to 36 mgd would need to go through reverse osmosis treatment. Reverse osmosis treatment would result in production of about 2.6 to 5.4 mgd of saline brine, with salinity concentrations of up to about 16,000 μmhos/cm EC. This volume of brine would require a tanker fleet of about 430 to 900 truck trips per day, assuming a capacity of 6,000 gallons per double-tank truck. In many areas a truck this large could not likely access the site because the wells are located in developed areas where trucks of this size may have limited access, and a smaller truck of about 3,000 to 4,000 gallon capacity would be required. This truck-size constraint would substantially increase the required number of needed truck trips.

The trucked brine could be brought to a temporary storage site or directly to a disposal facility. If a temporary storage area is used, brine could be transported via pipeline or truck to a disposal facility. Disposal facilities considered include in-County and out-of-County locations. The EIR stated that “brine disposal is the most serious technical challenge that renders this alternative infeasible.” The four brine disposal alternatives considered include a pipeline to off-site disposal, on-site brine ponds, on-site brine injection wells, and brine disposal by truck, as discussed below.

In County Disposal

Brine Injection Wells in Yolo County

Yolo County regulations limit deep-well injection of waste brines. Strong brine concentrates would require special well designs to operate without adversely affecting local groundwater supplies or other beneficial uses. Because County approval of this option is unlikely due to the County’s interest in protecting groundwater supplies, this alternative was not considered feasible.
Brine ponds in Yolo County would not be feasible because it would require the purchase of a very large area (about 3,000 acres) for the brine ponds. Additionally, the brine pond water would contain high salt loads and contaminants, including selenium. The expected high concentrations of selenium could have negative effects on waterfowl and other birds similar to those that occurred at Kesterson Reservoir when it received agricultural drainage water.

Out of County Disposal

Because discharge of the saline brine concentrate to local surface or groundwater is currently prohibited or unadvisable, transport to a suitable saline sink or ocean outfall therefore would likely be required. The possible means of brine disposal would be conveyance, either via pipeline or truck, to a treatment facility discharging to the San Francisco Bay or the Pacific Ocean. Currently the East Bay Municipal Utility District (EBMUD) accepts brine waste from industrial facilities in the San Joaquin Valley.

Pipeline to Off-site Disposal

Quick calculations show that a pipeline to Carquinez Strait would make the total project cost over $1 billion (i.e. more than three times the cost of the proposed DWWSP). A pipeline to EBMUD would be an additional 20+ miles and incur associated additional costs. Because this alternative would cost three or more times the proposed DWWSP, this alternative was not pursued further.

Brine Disposal by Truck

Conveying the brine for disposal by truck would mean trucking the brine to a disposal facility that accepts brine. The closest facility is EBMUD located in Oakland, CA. To dispose of brine waste at EBMUD, it is expected that each truck would have a round trip of over 150 miles. In 2006, an industrial facility incurred a transportation and disposal cost of about $550 per tank truck load using the EBMUD facilities (Michael Boccadoro, personal communication, May 2006). The treatment cost component of this process is currently about $0.03 per gallon (Sophia Skoda, EBMUD, personal communication, September 2006). If similar costs were incurred by the Agency, the cost of brine transportation and disposal, calculated at 430 to 900 truck trips per day at $625 per truck trip ($550 in 2006 dollars escalated to 2010 dollars) would range from approximately $98 million to over $204 million per year, in 2010 dollars.

In the EIR, trucking was determined to be too expensive and impractical, and would produce significant environmental impacts.

CONCLUSION

In short, treatment of groundwater supplies was rejected because of well-site constraints and because the required removal and disposal of salts would be too costly, both financially and environmentally. Well-head treatment requires the acquisition of land adjacent to each well and may present several inconveniences to the public. Furthermore, the process of removing salts, and disposing brine waste once salt has been removed, results in high energy costs and a correspondingly large “carbon footprint.”
The proposed project was selected because it was the least cost alternative that met all three project objectives (improve drinking water quality; improve water supply reliability; and improve quality of wastewater discharge).