2.4 Contaminant Transport Assessment and Management (CONTAM)

The Contam research area focuses on developing technology to observe and manage mass and energy distributions and fluxes across a range of temporal and synoptic scales. In 2010–2011, the contaminant transport group continued its emphasis on integrated sensing and model-driven analysis. Projects continued to focus on high resolution river observation and modeling with respect to whole stream metabolism, groundwater-surface water exchanges, and hydrodynamic mixing. In addition, new emphases have emerged in the areas of (1) managed aquifer recharge aimed at increasing the sustainability of groundwater supplies and (2) integrating remote (aerial) sensing products with CENS embedded sensing strategies in order to extend our approaches to larger spatial scales (i.e., watershed).

The **major accomplishment** in the Contam application area for 2010–2011 was **the installation of a major new observational network at a managed aquifer recharge site in Fresno, CA**. After more almost 2 years of uninterrupted data from the Palmdale water reclamation and irrigation site, and the dairy wastewater irrigations sites near Merced, CA, we shifted sensing resources to the managed aquifer recharge site in Fresno, CA. This newest Contam site is called **MARnet** (managed aquifer recharge network). One of the observational nodes is shown Figure 3 during the initial flooding of the infiltration pond. At this site, we aim to successfully demonstrate integrated modeling and observational techniques which **will enable managed aquifer recharge with reclaimed water to be used more readily in arid and semi-arid climates, thereby increasing the sustainability of water resources**.

Figure 3. The new CENS-CITRIS managed aquifer recharge network (MARnet) prototype presently installed at the Fresno city wastewater treatment facilities.

Overall the Contam group focused on three projects over the past year, including (1) the new managed aquifer recharge site, (2) continued development of high temporal resolution dissolved oxygen data collection and net daily metabolism estimation at high spatial resolution, (3) developing new approaches to integrating CENS' embedded sensing approaches with larger scale remote sensing data.

After transitioning sensor to the MARnet site, we also focused effort on the interpretation of long-term data at the Palmdale and Merced dairy sites. Findings from these sites are summarized in one doctoral dissertation and two M.S. theses. These focus on the development and testing of long-term simulation models and data assimilation methods for forecasting the effects of irrigating with reclaimed water on groundwater quantity and quality in terms of nitrate and salinity levels, and on the long-term problem of soil salinization. Our results indicate that **by hardening the demonstrated approaches we can build robust embedded sensing systems reporting higher level information than simply moisture changes over time, reporting instead on the sustainability of current practices** and proposing modifications to improve upon the current approach. Furthermore, to enable scale up of the MARnet approach we have developed parsing algorithms that sort hydrologic and geospatial properties and socioeconomic features over large areas, such as counties, to identify the most promising areas for developing MAR operations. In the coming year this aspect of Contam research will continue to operate and assess the MARnet prototype while working with local water agencies to identify additional test sites. In particular, we are interested in identifying a floodwater diversion site to contrast with the existing wastewater reclamation site.

In the second project area, we have extended our aquatic sensing capabilities on the Lower Merced Rivers, having installed a long-term water quality monitoring station in September 2010. This station is enabling us to continuously examine water quality parameters at high temporal resolution in a critical agricultural reach of the river. In addition, we have continued our synoptic monitoring efforts over this river reach on a roughly quarterly basis, including both water quality and imagery to capture human influences in the form of inputs (canals, drain pipes) and outputs (pumps and diversions). **By combining the temporal and synoptic data we are learning to separate the influences of human disturbances from natural background processes.** At this time we are focusing mainly on temperature, dissolved oxygen (DO), and nitrate changes in the river, and using the ecosystem metrics associated with net daily metabolism (primary production, community respiration) as a method for quantifying the river's response to natural and anthropogenic disturbances. Most recently we have been able to autonomously detect changes in metabolism over a wide range of flow releases from upstream reservoirs.

The third Contam project area over the past year focused on the integration of embedded and remote sensing approaches in both terrestrial and aquatic systems For terrestrial systems, we continued pursue the objective of classifying ecosystem change over relatively short time periods. Our most successful approach to date involve modifying an existing algorithm (multivariate alteration detection or MAD) to include an object-based approach. The latter allows us to better filter false change detections. We tested the algorithm using high resolution aerial imagery of a managed wetland area in Central California. Our new approach enabled us to filter out false changes better than the MAD algorithm alone. The object-based aspect of our algorithm allows us, for example, to notice that certain vegetation objects (small trees or bushes) cannot spread or move over short time periods, and therefore identifies potential changes in such objects a spurious. Overall, the modified object-based MAD (OB-MAD) algorithm successfully classified relatively subtle changes in wetland plant community structure over a period of only one year. **By enabling ecosystem managers to identify the onset of change over shorter time periods, we can empower them to enact operational changes which have a better chance of preserving desirable ecosystem functions before the movement toward change become irreversible**.