The Lodi Water Pollution Control Facility is located in an agriculturally dominated region of the northern San Joaquin Valley, where both human and naturally-occurring factors are expected to affect groundwater quality.

In addition, land application of wastewater has occurred at the WPCF site since the 1940's. This long-term practice also has the potential to affect groundwater quality.

The focus of this study was to define the potential impacts associated with these various factors and to provide recommendations for further evaluation.

Purpose and Objectives

- Establish Existing Regional and Site-Specific Groundwater Quality Conditions
- Identify Sources and Relative Contributions of Nitrate and Salinity

This study is intended to describe the existing onsite and offsite conditions with respect to the potential for groundwater impacts.

The pollutants that were specifically addressed are nitrate and salinity.

Overview of California Groundwater Protection Policies

- Anti-degradation Policy Requires that Any Change in Water Quality:
  - Is consistent with "maximum benefit to the people of the State"
  - Will not unreasonably affect beneficial uses; and
  - Will not result in water quality that exceeds the applicable objectives or background water quality, whichever is greater.
- Dependant Upon Background Conditions
- Compliance is Technology Driven and Requires Best Practicable Treatment or Controls (BPTCs)

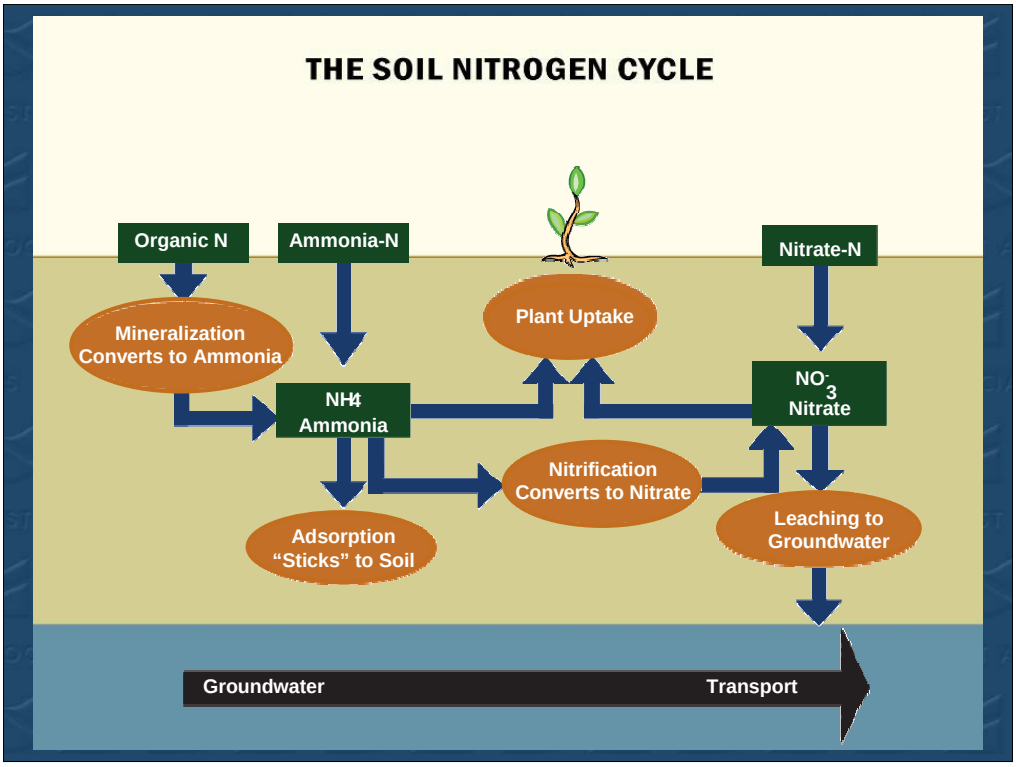
The State's Anti-degradation policy requires that water quality be maintained to protect the beneficial uses.

Such protections are defined by either the water quality objective or the background water quality, whichever is greater.

Therefore, the first study objective (i.e. Establish Existing Regional and Site-Specific Groundwater Quality Conditions) will help to define the background conditions and therefore the Water Pollution Control Facility compliance with this standard.

If a compliance issue is identified, the City will need to implement appropriate control measures (or BPTCs).

Therefore, the second study objective (i.e. Identify Sources and Relative Contributions of Nitrate and Salinity) will be used as a basis for defining the BPTCs appropriate for the White Slough WPCF.



This slide presents an overview of a simplified soil-nitrogen cycle.

Nitrogen added to soil environments can be in the form of organic nitrogen, ammonia nitrogen, or nitrate nitrogen. Each of these components can be modified in the soil environment and has a different fate and transport mechanism.

This figure does not represent all of processes that affect nitrogen speciation in a soil environment. Denitrification (conversion of nitrate to nitrogen gas), volatilization (release of nitrogen gas to the environment), and fixation of nitrogen gas from the environment are not shown. Nevertheless, this figure demonstrates the complexity of evaluating the fate and transport of nitrogen in the soil environment and the potential for nitrate to leach into groundwater.

Salinity

- Salinity is the Dissolved Mineral (or Salt) Content of a Body of Water
- Minerals Dissolved in Water Have a Positive or Negative Charge
- Electrical Conductivity (EC) is a Measure of This Charge (and Therefore is a Measure of the Dissolved Mineral Content)
- Major Components of EC are Calcium, Magnesium, Sodium, Bicarbonate, Chloride, and Sulfate

EC Content of Water Bodies

Body of Water	Typical EC, µmhos/cm
Distilled Water	3
Pure Rainwater	10
Lake Tahoe	90
Sacramento River	150
San Joaquin River	500
Western Delta Water (Brackish)	2,000
Pacific Ocean	>40,000
Great Salt Lake	158,000

Salinity or Electrical Conductivity (EC) is quite variable in water bodies found throughout the natural environment..

Water Quality Objectives for Groundwater

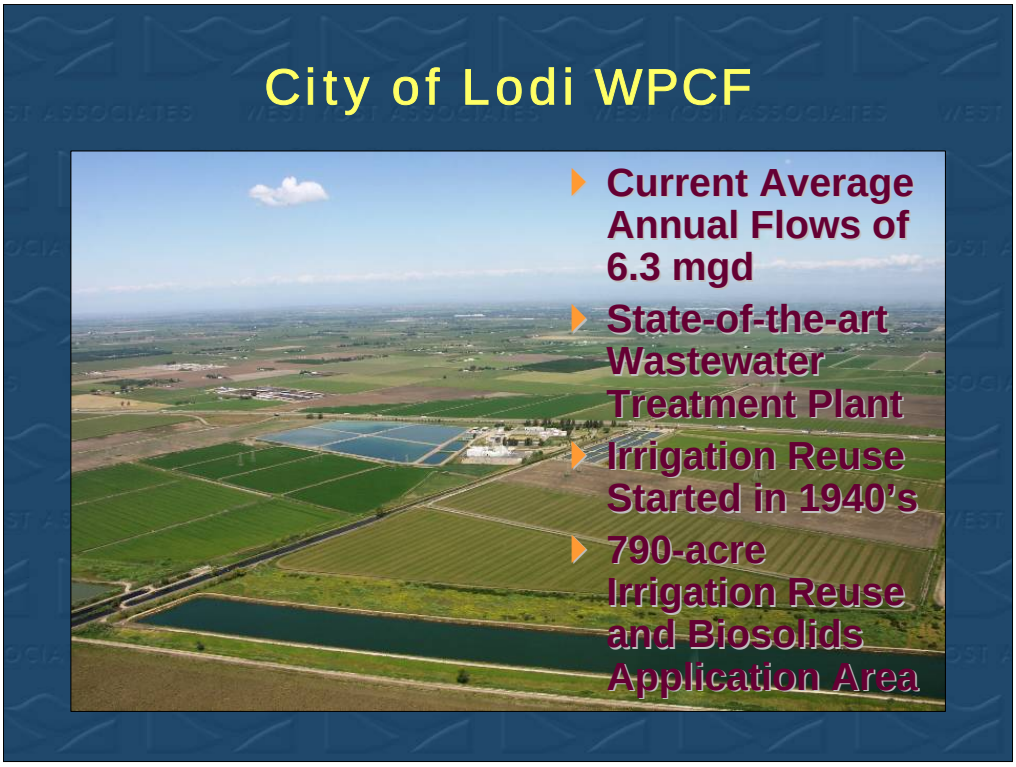
Constituent	Concentration	Applicable Objective
Nitrate	10 mg/L	Primary MCL
EC	700 µmhos/cm	Agricultural Goal
Sodium	69 mg/L	Agricultural Goal
Chloride	106 mg/L	Agricultural Goal

These are the water quality objectives applicable to groundwater in the Region of the Lodi Water Pollution Control Facility. These objectives set a goal to which groundwater quality should be maintained. However, both natural and anthropogenic influences can result in groundwater quality that does not meet these objectives. Therefore, an understanding of these influences is needed to determine whether additional actions can be employed to improve groundwater quality.

A basic review of the Water Pollution Control Facility is needed to understand the potential impacts associated with its operation.

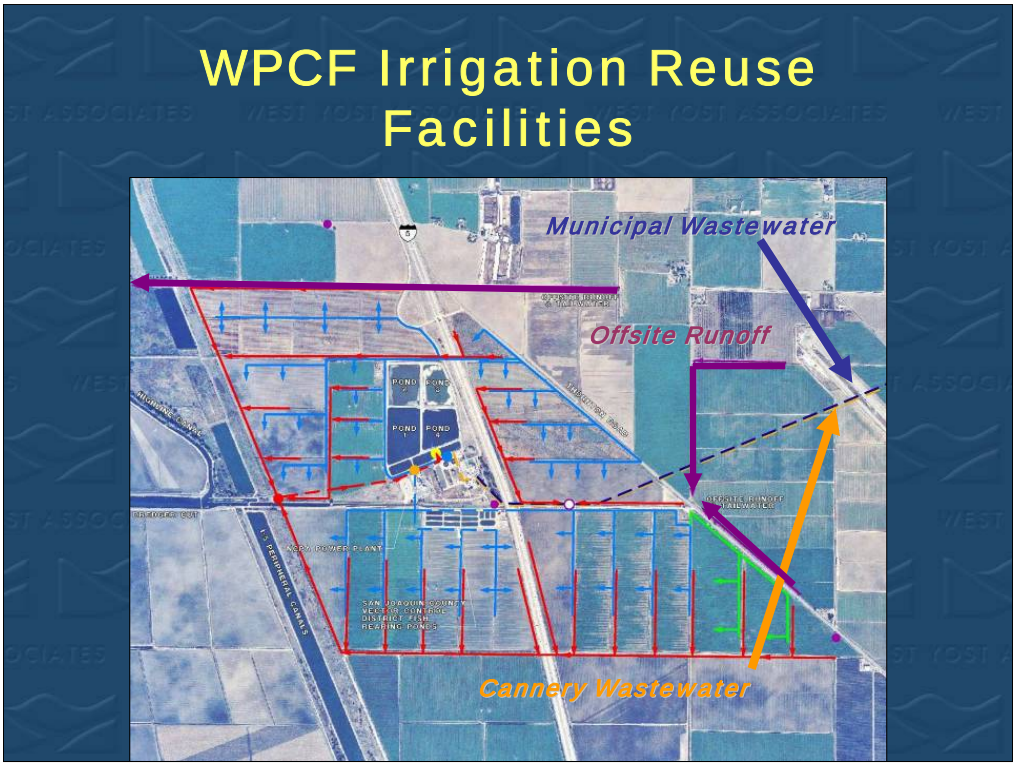
Major considerations include:

- Land application practices (total area, distribution, history)
- Sources of irrigation water



The City of Lodi operates a state-of-the-art wastewater treatment facility that treats all of the wastewater generated within the City.

The City has been practicing agricultural reuse of treated wastewater since the 1940's. Today the City operates a 790-acre agricultural reuse and biosolids application area.



This graphic shows an overview of the City's agricultural irrigation reuse facilities.

The three primary sources of flow that are used for agricultural reuse are as follows:

•Treated municipal wastewater from the City

•Un-treated industrial wastewater, primarily from a large cannery

•Stormwater and agricultural runoff collected from areas within the City and from properties located adjacent to the Water Pollution Control Facility.

Municipal wastewater not used for agricultural irrigation is discharged to a small channel of the Sacramento-San Joaquin River Delta.

The conveyance facilities onsite consist of subsurface pipelines, and concrete and earthen-lined irrigation ditches.

Individual field areas are irrigated via flood irrigation. All agricultural and stormwater runoff generated onsite is collected year-round and returned to the onsite storage ponds.

Environmental Setting

A basic review of the environmental setting is needed to understand potential groundwater impacts near the Water Pollution Control Facility.

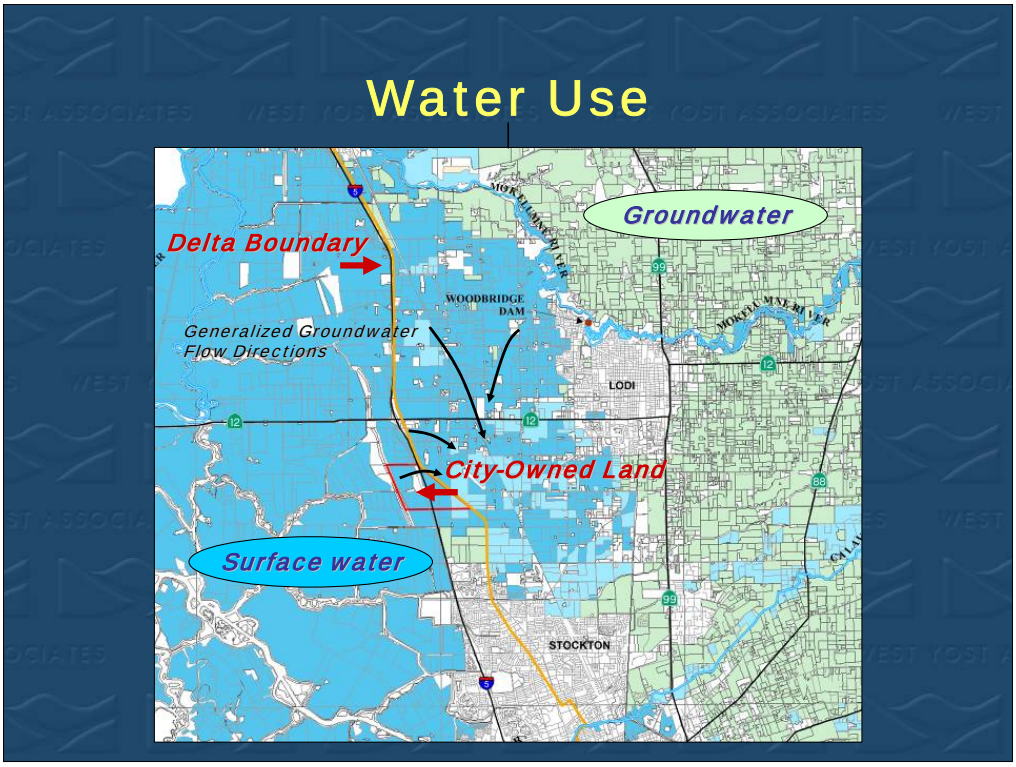
Major considerations include:

- Pre-development physical geography
- Land and water use

Focusing on groundwater, major factors include:

- Prevailing regional groundwater flow directions
- Local variations in flow
- Regional groundwater quality
- Local variations attributable to current land use

These topics will be presented more thoroughly through the next slides. We'll conclude with a few thoughts on further investigation of groundwater.



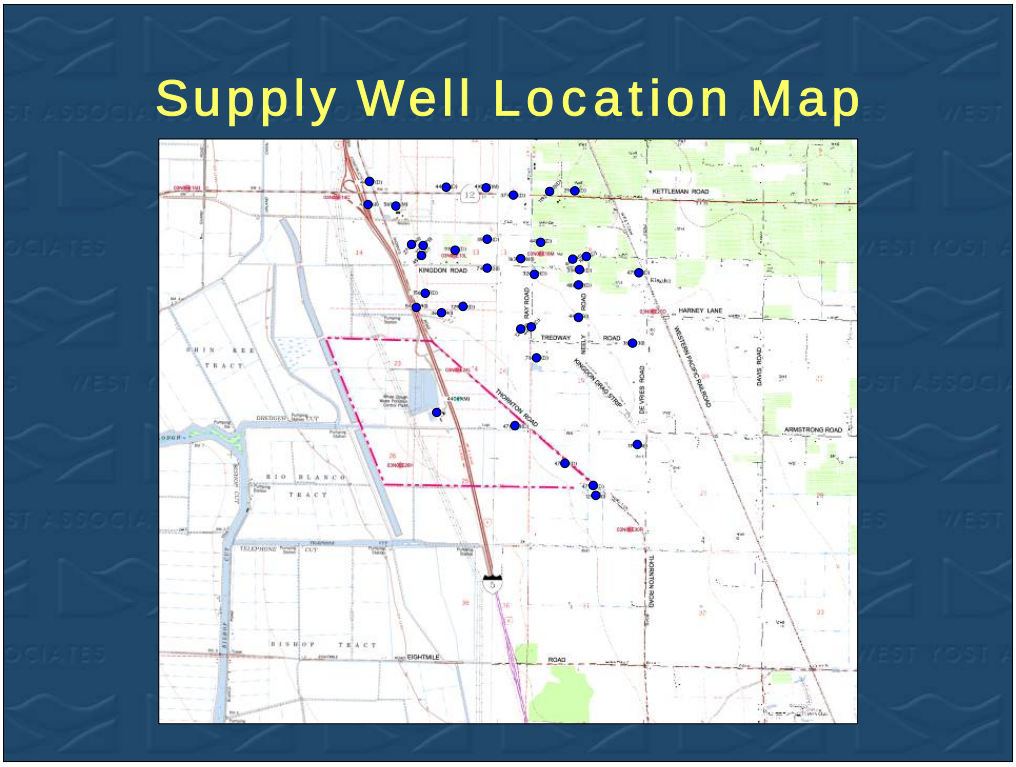
This graphic shows the broad divisions in geographical features and land and water use in the vicinity of the White Slough Pollution Control Facility.

The most significant geographical boundary is between the Delta and the adjacent Sierran alluvial plain (marked “Delta Boundary”).

Also shown are broad demarcations of water use based on DWR records. Surface water is used in the Delta area and in the Woodbridge Irrigation District. Groundwater is used to the east and in urban areas.

Much of land between the Water Pollution Control Facility and the Lodi urban area is within the Woodbridge Irrigation District the district; however, not all land is irrigated with surface water.

Generalized regional groundwater flow directions are also shown. We’ll talk more about these later.

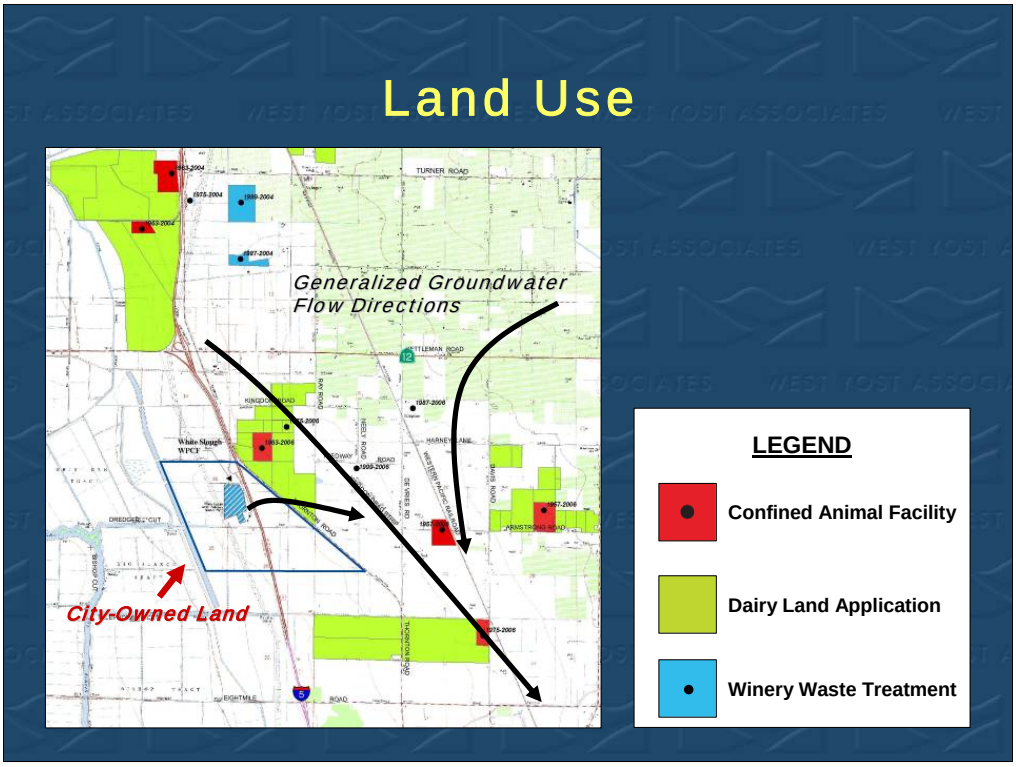


Shown here are supply wells in the vicinity of the White Slough Water Pollution Control Facility. The well information was obtained from the DWR well completion database. Some of the posted wells may no longer exist, and some wells that do exist may not be posted.

Although the pumping volumes are unknown, this shows that groundwater makes up a significant proportion of the local water supply, contrary to the more generalized DWR water use information on the previous slide.

Most of the groundwater pumping in the vicinity of the facility appears to be to the northeast of the facility.

This pumping probably influences groundwater flow directions locally.

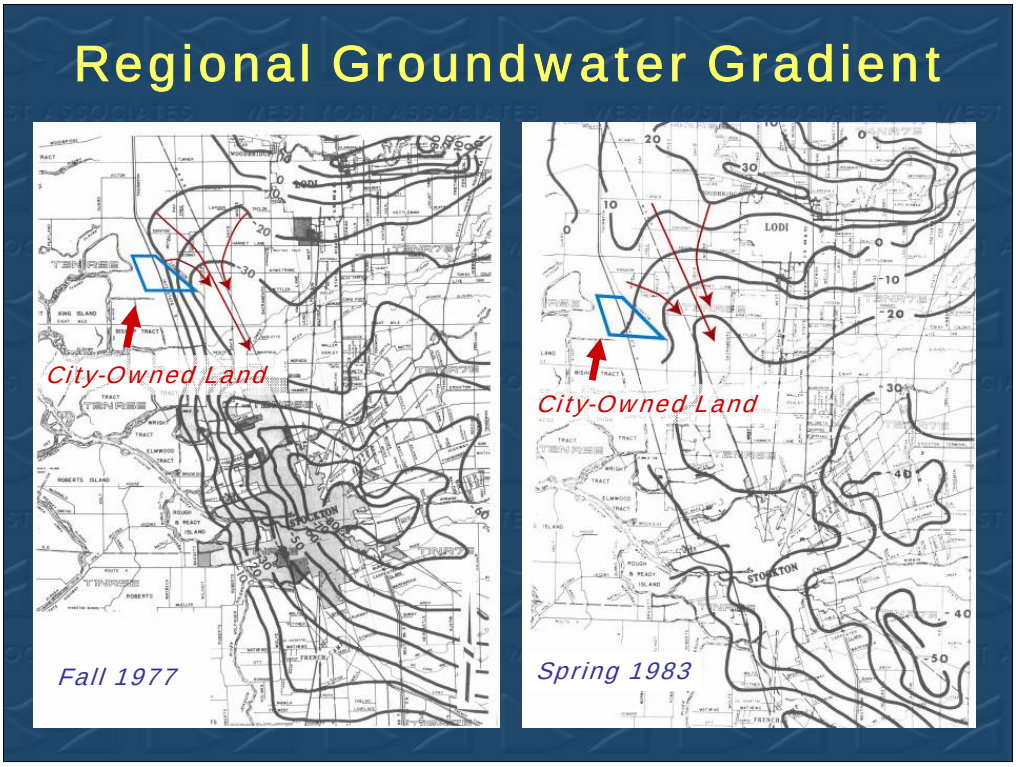


Land use in the vicinity of the White Slough Water Pollution Control Facility includes significant dairy production, as well as wine making. Both land uses produce solid and liquid wastes that are land applied.

Land application of these wastes could lead to groundwater impacts that are very similar to those which might be attributable to the White Slough Water Pollution Control Facility. These include:

- Nitrogen compounds
- Salinity

Groundwater flow converges on the Stockton area, due to pumping. This regional convergence indicates that impacts from various potential sources near the facility may be mixed as groundwater flows away from the sources toward the drawdown caused by pumping.



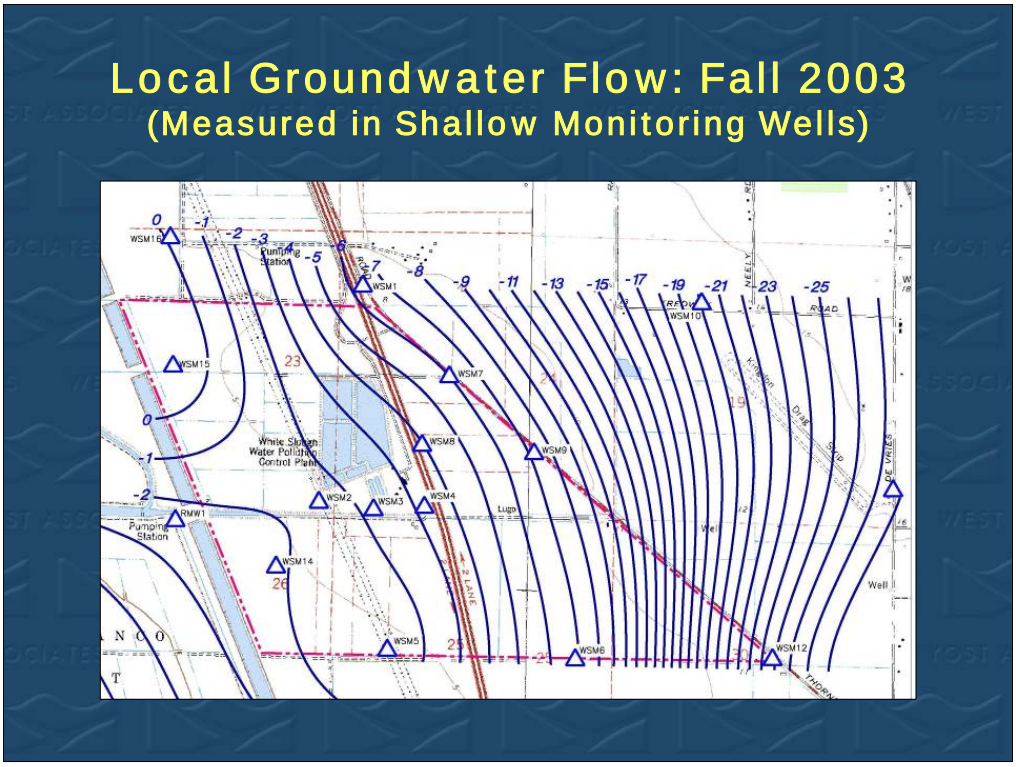
These maps shows contours of equal groundwater elevation for fall 1977 and spring 1983 measured in supply wells. The contour lines are analogous to land surface elevation contours on a typical USGS map. Groundwater flows down slope just as a ball would roll down slope. Therefore, red lines drawn perpendicular to the black contour lines approximate the groundwater flow direction.

The contours shapes, and, therefore flow directions, are typical of all years on record. These two time periods define the range of groundwater elevations in recent history. Some of the lowest groundwater elevations occurred in fall 1977 (following several y ears of drought), and some of the highest groundwater elevations occurred in spring 1983 (following several years of relatively heavy rainfall).

The figures show the southeasterly of groundwater flow near the White Slough Water Pollution Control Facility.

Groundwater originating from various sources converges as flows towards Stockton.

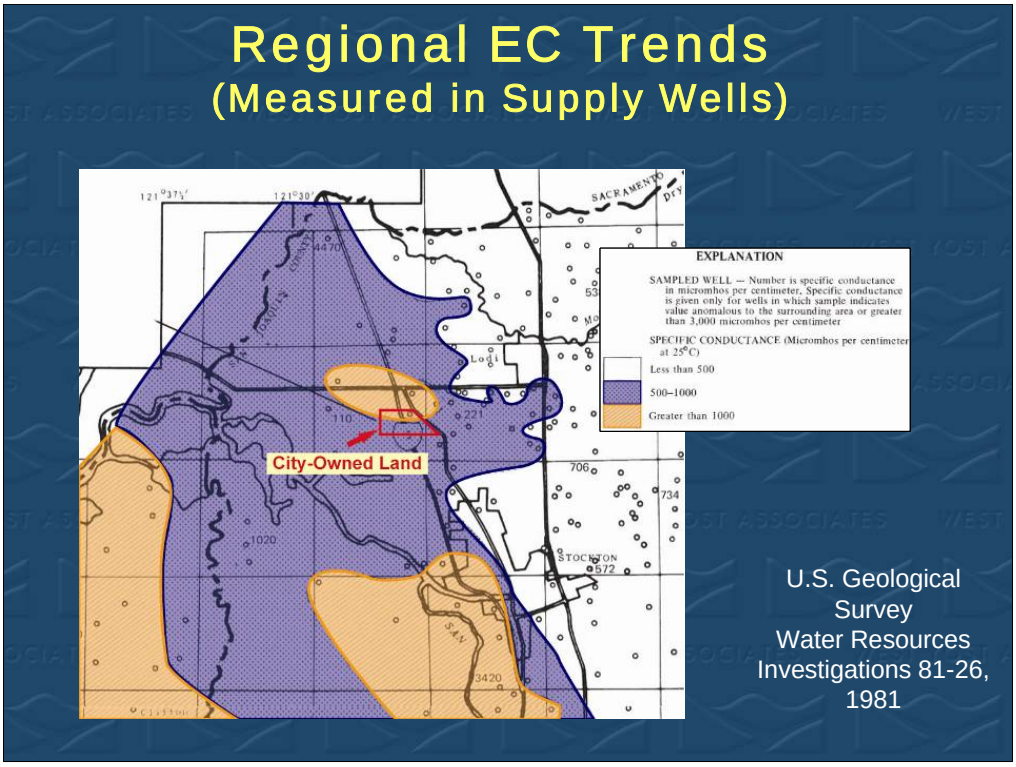
Groundwater recharge is evident to the north, in the vicinity of the Mokelumne River, and to the west, in the Delta area. Recharge rates and groundwater flow velocities in the west may be limited by the low permeability of the Delta soils.



This slide shows local groundwater elevations measured in shallow monitoring wells near the Water Pollution Control Facility.

In general flows from the facility is to the east/southeast. However, northeast of the treated effluent storage ponds, groundwater flow directions may be influenced by local groundwater pumping. Flow is northeasterly in this localized area.

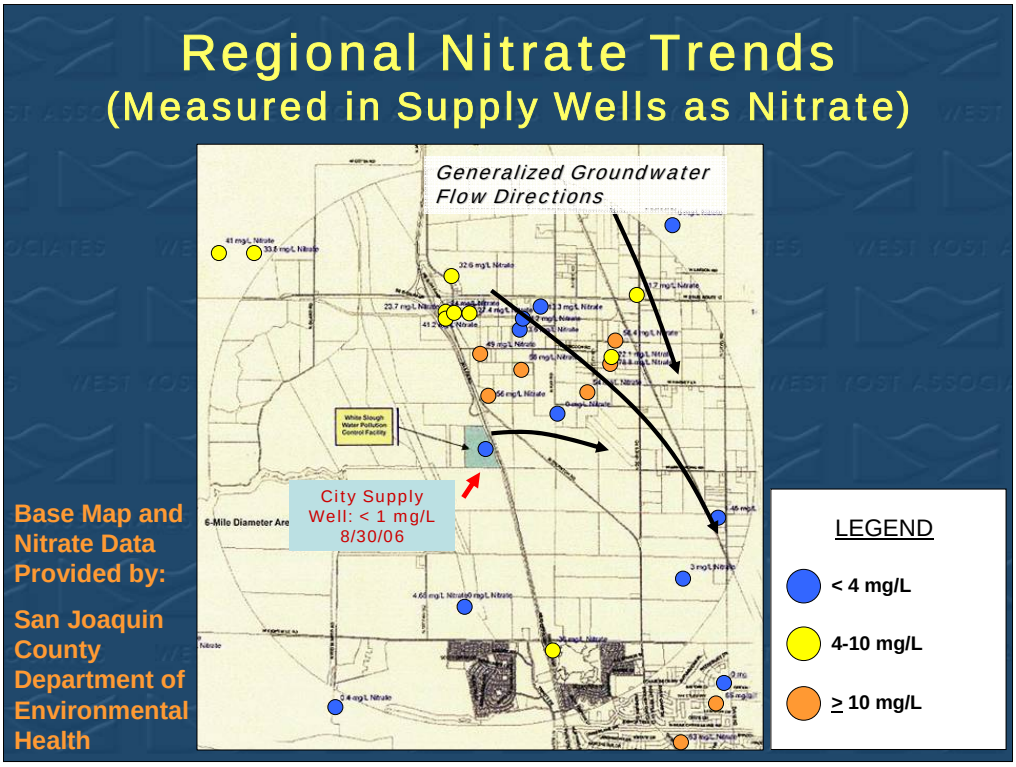
Groundwater quality is influenced by regional and local conditions.



Elevated levels of salinity are geographically associated with the Delta.

The impacts are reported by USGS to extend hundreds of feet below land surface. The highest concentrations are shown along the margins off the Delta.

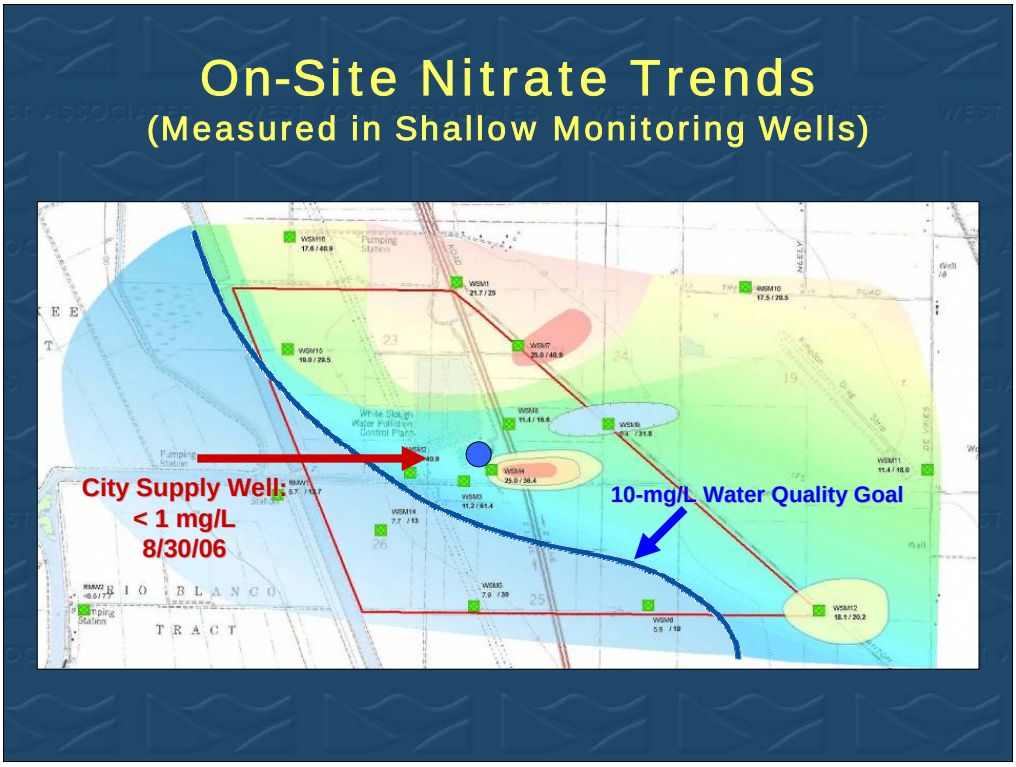
These Regional salinity patterns are thought to be the result of tidal affects in the Delta waterways that have brought high-saline waters into the area. Today, continuous flows from Sierra riverine sources keep tidal flows from transporting saline waters this deep into the Delta. Therefore, saltwater impacts may have been more severe in predevelopment times due to lower dry season flows in most Sierran Rivers.



Nitrate results were provided by the San Joaquin Departmental Health for supply wells and development projects.

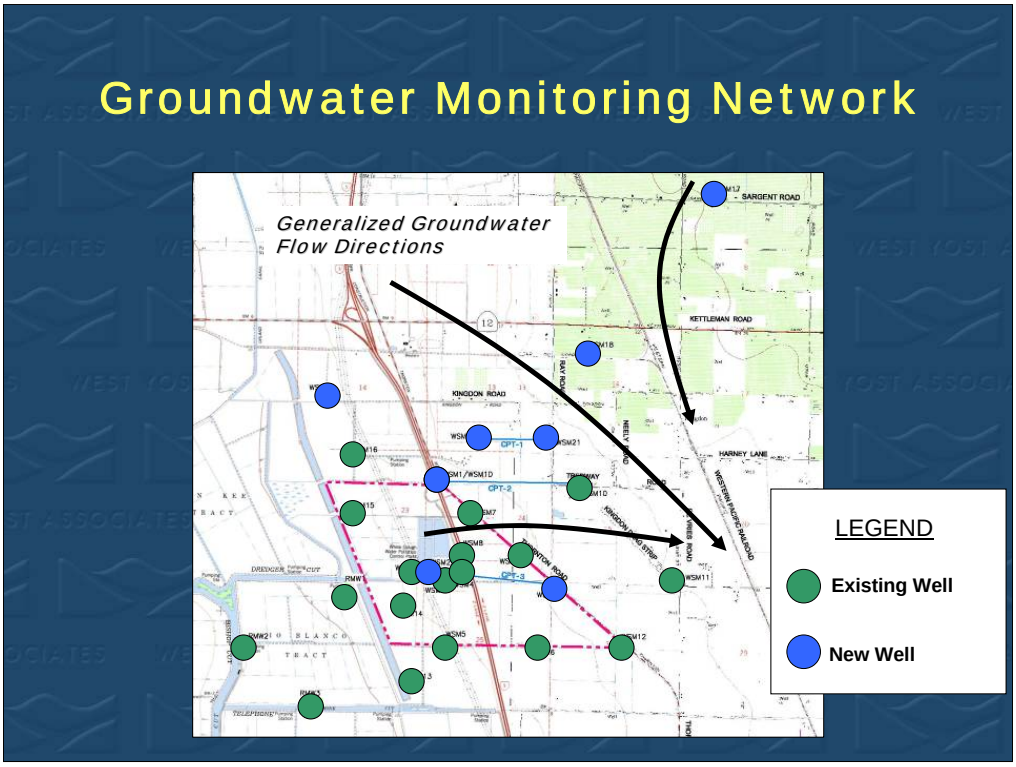
Concentrations exceeded the 10-mg/l water quality standard for nitrate in supply wells to the northeast of the Water Pollution Control Facility (orange dots). Groundwater does not appear to flow from the facility to all of these supply wells.

A supply well at the facility had a nitrate concentration of less than 1 mg/L on August 30, 2006.



Nitrate concentrations reported for the shallow watertable wells at the Water Pollution Control Facility exceed the 10-mg/l water quality standard.

A deeper supply well at the facility had a nitrate concentration 10 times less than the 10-mg/l water quality standard.



The City of Lodi is considering additional monitoring wells to augment its existing network of watertable monitoring wells.

Potential sources of groundwater degradation associated with the Water Pollution Control Facility include the following:

•Leaching of wastewater conveyed in the City's influent sewers (if significant deterioration has occurred)

•Leaching from the onsite wastewater storage ponds

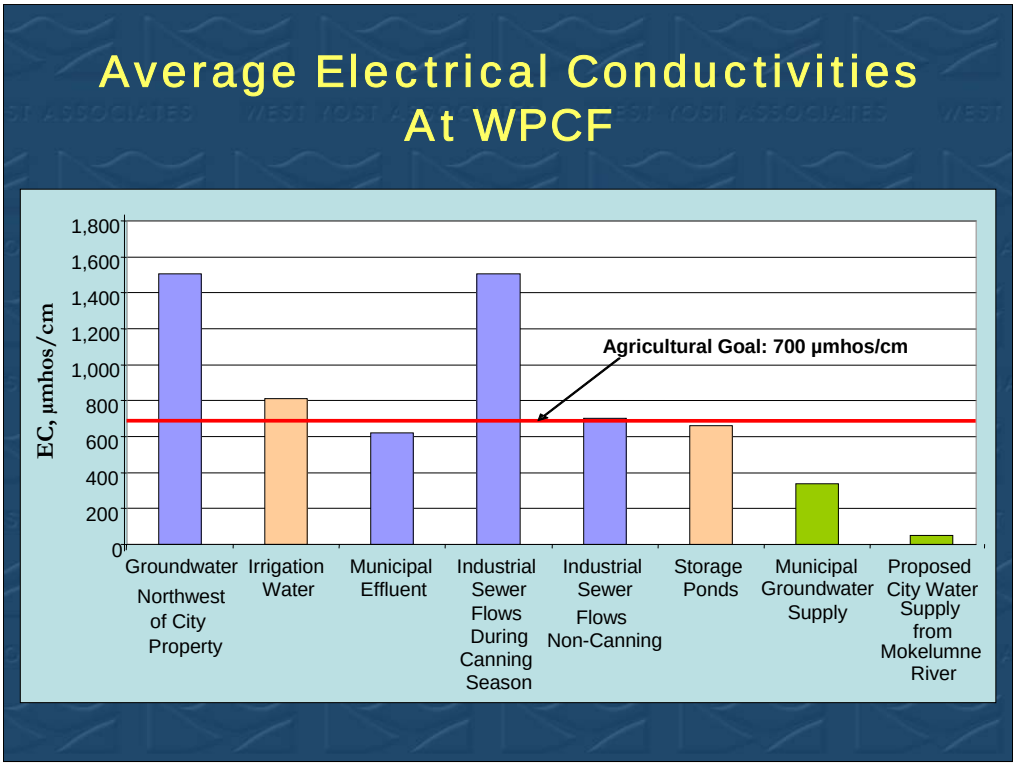
•Leaching associated with over-applications in the agricultural reuse area.

The following discussion addresses additional controls that are recommended to reduce the potential for impacts from these sources.

Both the industrial and municipal sewers were constructed over 50 years ago.

In recent years, the City has observed significant deterioration in these facilities, resulting in emergency repairs.

The City is committed to repairing and/or replacing other portions of these sewers that are found to be deteriorated.



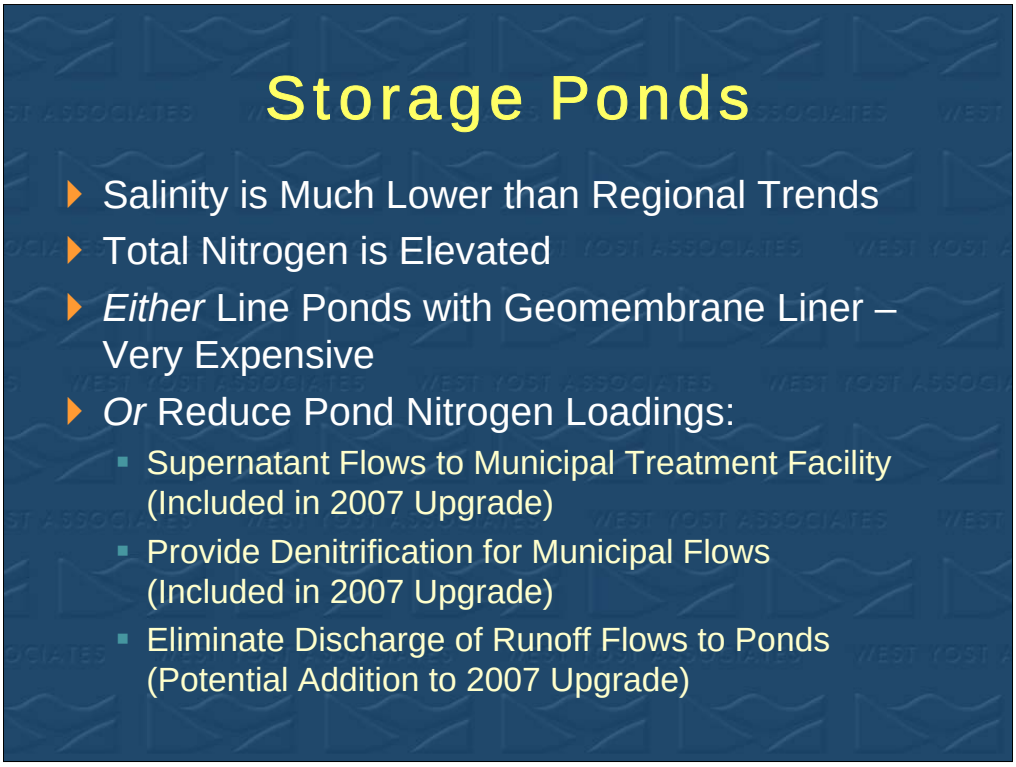
In addition to leaching from the influent sewers, there is the potential for salinity (measured as electrical conductivity) impacts to occur as a result of leaching from the storage ponds and/or the land application areas.

A review of shallow groundwater quality to the northwest of the Water Pollution Control Facility shows elevated salinity levels that are not attributable to the City's operations. As discussed previously, this salinity is attributed to historic tidal affects in the Delta that brought high-saline waters into the area.

The primary sources of salinity at the WPCF is from the municipal effluent and industrial wastewater. Industrial wastewater during the canning season can have very high salinity levels. However, prior to land application, this high salinity water is blended with municipal wastewater, resulting in relatively low salinity in the applied irrigation water.

A review of salinity levels in the City's storage ponds and applied irrigation water shows that levels are much lower than groundwater.

The City is considering the implementation of a project to use surface water from the Mokelumne River as a portion of the City's future water supply. If this were to occur, the salinity of the municipal wastewater would decrease proportionally.



The primary source of water stored in the onsite ponds is municipal effluent. Therefore, the water stored in the onsite ponds has a much lower salinity than underlying groundwater.

Elevated nitrogen levels are observed in the pond, and additional control measures are recommended.

Based on a review of available data, the City should be capable of significantly reducing nitrogen loadings to the storage ponds through the implementation of three planned/potential projects. These modifications are planned to be online by early 2009.

Irrigation Reuse Area

- Salinity is Lower than Regional Trends
- No Strong Correlation Between Nitrogen Loading and Groundwater Nitrate
- Other Factors Must Be Considered
  - Depth to Groundwater
  - Nitrogen Transformations in Soil and Groundwater
  - Other Sources of Nitrogen
  - Spatial and Temporal Distribution of Sources
- Options for Additional Nitrogen Controls:
  - Adjust Loads to Meet Site-Specific Uptake
  - If Necessary, Modify Facilities for Better Distribution

As discussed previously, the blended irrigation water has a much lower salinity the underlying groundwater. (Groundwater salinity is affected by naturally-occurring saltwater intrusion that is associated with historic Delta tidal influences)

The City has worked to control applied nitrogen loadings to the irrigation areas such that they do not exceed crop uptake rates. A review of available data does not yield a strong correlation between historic loadings and nitrogen trends observed in groundwater.

However, several factors can affect the fate and transport of nitrogen. Additional controls should be considered due to the observed elevated nitrogen levels in the region.

The City is working to develop site-specific field nitrogen loading rates for the City-owned property. Future loadings will be adjusted to meet these requirements. If following this adjustment nitrogen is still a concern, the City will consider additional controls.

Potential Irrigation Reuse Area Nitrogen Load Reduction Strategies

- 2007 Upgrade
  - Effluent Nitrate Reduction
  - Supernatant Treatment
- Potential Additional Controls
  - Expand Irrigation Area
  - Alternative Biosolids Treatment and/or Disposal
  - Improve Irrigation Water Distribution

The City will likely need to reduce the total amount of nitrogen applied to the land areas to meet the adjusted loading rates.

At least a portion of this reduction will occur under planned projects.

Additional evaluation is need to determine whether other nitrogen reduction strategies are needed, especially as flows and loadings increase in the future.

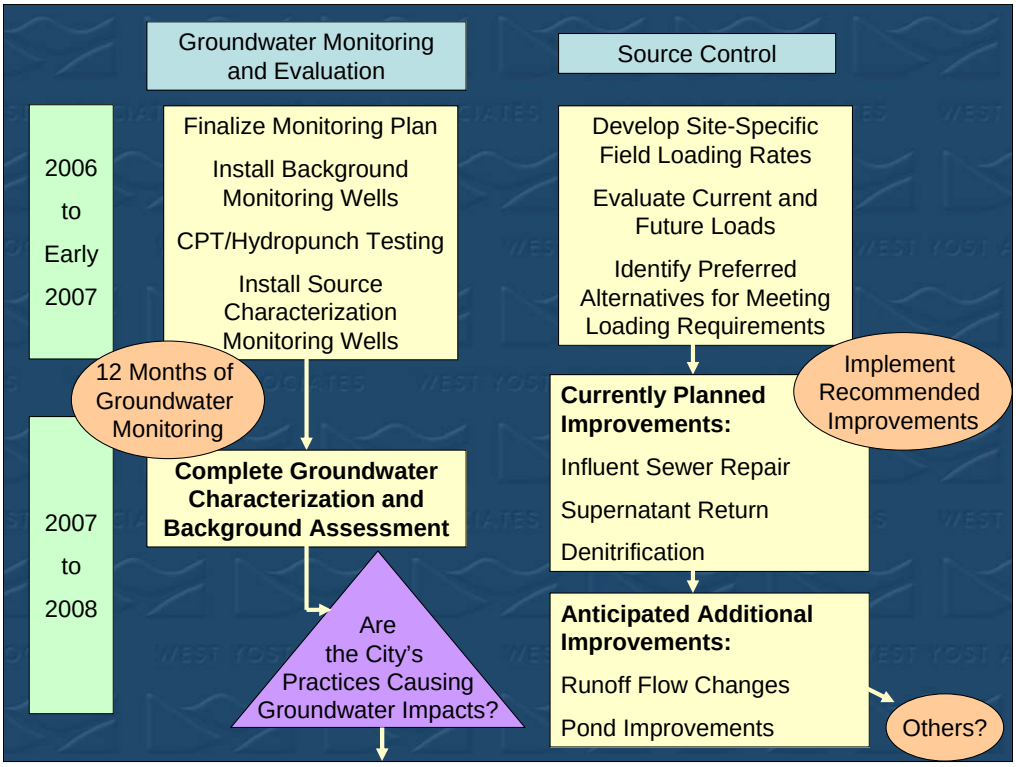
The City will complete a cost versus benefit analysis to identify the most cost effective means of meeting future nitrogen loading rates for the field areas.

Summary and Conclusions

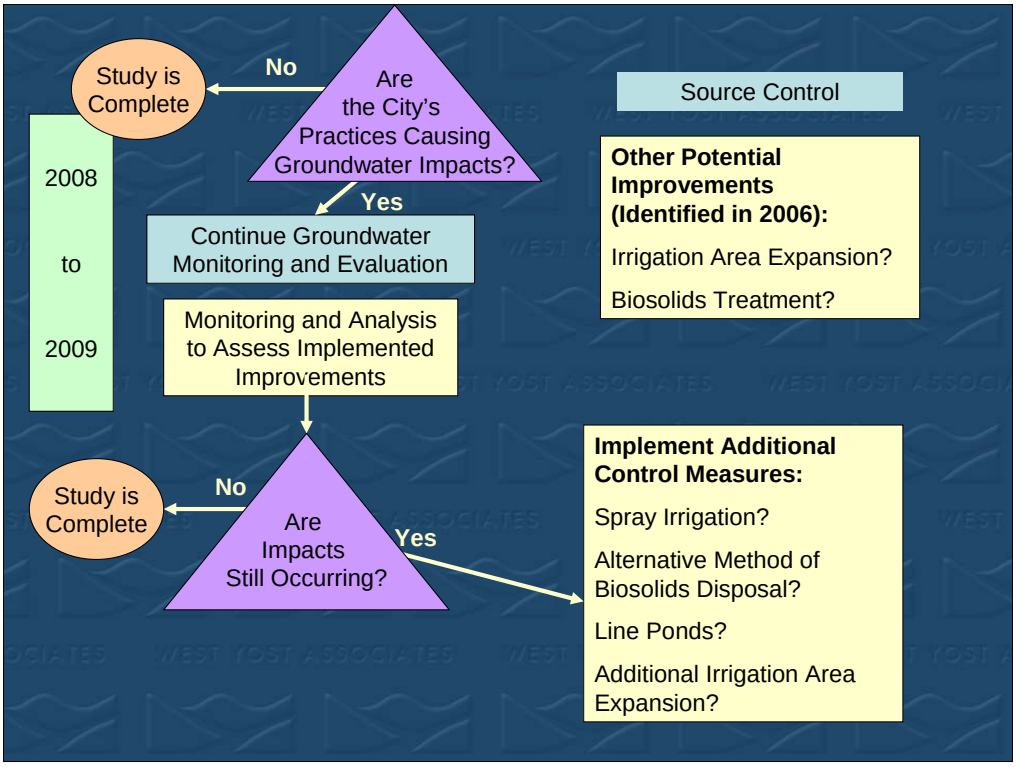
- Groundwater is Strongly Influenced by Regional Conditions
- Further Investigation is Needed To Confirm Background Concentrations
- Some Source Controls Are Being Implemented
- Detailed Cost/Benefit Evaluation of Additional Controls is Recommended Next Step
- Evaluation Should Account for Planned Load Changes

This study demonstrated that there are many factors affecting groundwater in the region of the Water Pollution Control Facility, and further evaluation is needed to better understand these factors.

The City is also working toward identifying cost-effective solutions for addressing potential impacts associated with City operations.



The City has identified a timeline for addressing groundwater concerns in the region of the Water Pollution Control Facility. As this project moves forward, the City will refine and update this timeline.


Study is Complete
No
Are the City's Practices Causing Groundwater Impacts?
Yes
Source Control
2008
to
2009
Continue Groundwater Monitoring and Evaluation
Other Potential Improvements (Identified in 2006):
Irrigation Area Expansion?
Biosolids Treatment?
Monitoring and Analysis to Assess Implemented Improvements
Study is Complete
No
Are Impacts Still Occurring?
Yes
Implement Additional Control Measures:
Spray Irrigation?
Alternative Method of Biosolids Disposal?
Line Ponds?
Additional Irrigation Area Expansion?

For more information Please Contact:

PWDEPT@LODI.GOV