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Subgroup: Practice Resources Stewardship

Chapter # Recharge Areas Protection

Recharge areas are those areas that provide the primary means of replenishing groundwater. Good natural recharge areas are those where good quality surface water is able to percolate unimpeded to groundwater. If recharge areas cease functioning properly, there may not be sufficient groundwater for storage or use. Protection of recharge areas requires a number of actions based on two primary goals. These goals are (1) ensuring that areas suitable for recharge continue to be capable of adequate recharge rather than covered by urban infrastructure, such as buildings and roads; and, (2) preventing pollutants from entering groundwater in order to avoid expensive treatment that may be needed prior to potable, agricultural, or industrial beneficial uses.

Protection of recharge areas is necessary if the quantity and quality of groundwater in the aquifer are to be maintained. However, protecting recharge areas by itself does not provide a supply of water. Recharge areas only function when aquifer storage capacity is available, and when regional and local governments and agencies work together to secure an adequate supply of good quality water to recharge the aquifer. Protecting existing and potential recharge areas allows them to serve as valuable components of a conjunctive management and groundwater storage strategy.

Other Volume 2 strategies related to recharge areas protection are urban runoff management (Chapter #), groundwater remediation/ aquifer remediation (Chapter #), and conjunctive management and groundwater storage (Chapter #). Management of a natural resource such as water requires integration of all management efforts.

In simple terms, a groundwater system consists of three component parts—recharge areas where surface water moves to groundwater, storage media consisting of aquifers that store groundwater, and discharge areas consisting of wells, springs, and rivers. As with all natural systems there is an almost infinite variety in the way these components relate to each other in the real world.

PLACEHOLDER Box x Terminology

Natural recharge takes place without interference or assistance from people. Artificial recharge is additional recharge that takes place with the assistance of people. For instance, some artificial recharge occurs through unlined ditches. Artificial recharge may be managed in a number of ways. Artificial recharge can take place in areas where natural recharge occurs (stream channels or alluvial fans) by increasing flow volume and decreasing flow velocity. Artificial recharge can also take place in structures built specifically for increasing recharge. These structures are called recharge basins, spreading basins or replenishment basins or areas. The goal of all artificial recharge is to increase the rate of infiltration or percolation of surface water into groundwater while maintaining the quality of the water so that it can be sued for the intended purpose when it is extracted.

Managed Recharge Areas in California

The first documented artificial recharge program in California began in Los Angeles basin in 1889. Beginning in the early 1900s, water agencies operated recharge areas in the San Joaquin Valley. Additional areas for artificial were established later in Southern California and San Francisco Bay Area. While a certain amount of recharge takes place in many areas, the areas that were chosen by water management agencies were those areas that met three conditions. First, the sediment is coarse enough to allow surface water to infiltrate at a higher rate than through finer sediments. Second, there is hydraulic continuity between the recharge area, the aquifer in which the groundwater is stored and transported, and the discharge area where wells are built to extract the groundwater. Third, a local agency had access to the land on which these first two conditions existed.

The three types of recharge that are possible are in-stream, off-stream, , and injection wells. In-stream recharge allows water to percolate through the stream bed itself. Off-stream recharge uses suitable sites outside the streambed. In some operations, the water must be pumped some distance from its source to the off-stream recharge area. Injection wells are used at locations where the cost of large tracts of land would be prohibitive.

Each method has pros and cons. In-stream and off-stream spreading basins eventually become clogged by suspended fine-grained material carried in the surface water. As a result the rate of recharge declines considerably, making the basin much less effective. Those fines must somehow be removed. In addition, in urban areas the cost of land necessary for spreading basins is often prohibitive. Injection wells are expensive to build but they may be feasible in urban areas where the cost of land is high. However, they are also subject to clogging unless the water is treated and turbidity is minimal, and air is not entrained.

The State Water Resources Control Board has compiled a map showing the areas of California where published reports indicate there is a hydraulic continuity between the ground surface and groundwater. These areas may be hydrogeologically suited for use as recharge areas if they meet the 3 conditions cited above—coarser sediments, hydraulic continuity between the recharge area and the discharge area, and local agency ownership. Contamination of these areas would lead to contamination of the groundwater in the aquifer. The map may be viewed at http://www.waterboards.ca.gov/gama/.

Table #-1 shows current sites in California that are managed for artificial recharge.

Table #-1 Recharge sites in California

Agency	Type of recharge site
Arvin-Edison WSD	Offstream
Berrenda Mesa WD	Offsteam
Calleguas MWD	Injection wells
City of Bakersfield	Instream, offstream
Coachella Valley WD	Instream, offstream
Flintridge-Cañada	Injection well
Fresno County FC&WCD	Offstream, injection wells
Friant-Kern Water Users Authority	Instream
Kern Water Bank	Offstream
Los Angeles County DPW	Instream, offstream, injection wells
North Kern WSD	Offstream
Orange County WD	Instream, offstream, injection wells
Pioneer (KCWA)	Instream, offstream
San Bernardino County WC&FCD	Offstream
Santa Ana Watershed Project Authority	Offstream, injection wells

Agency	Type of recharge site
Santa Clara Valley WD	Instream, Offstream
Semitropic WSD	Offstream
United Water Conservation District	Instream, offstream

The size of existing recharge areas and the amount of groundwater that is artificially recharged annually is substantial, but there is no procedure in place to compile that number. The total amount of land devoted to spreading basins and offstream and instream recharge probably exceeds 50 square miles. The actual area is difficult to determine, partially because many diversion ditches and creeks are active artificial recharge sites during some periods of the year. These active recharge areas and other areas should be protected for recharge purposes.

For purposes of analysis and planning, actual and potential recharge areas can be assigned to 1 of 3 categories.

Category 1—Areas that are active recharge areas at the present time under the control of water management agencies. These areas are listed in Table 1 above. The infiltration rate at these areas is high and they are carefully managed to maintain that high infiltration rate and to protect the quality of the water that is being recharged. At most of these sites monitoring activities track groundwater levels, rate of movement of the recharged water into the aquifer and chemical changes.

Category 2—Areas that are known to have a fairly high infiltration rate, but that are not under the control of a water management agency. There may be little or no monitoring. Programs should be considered that monitor recharge, prevent potential contaminating activities, and educate the public about the importance of protecting the quantity and quality of their water supply.

Category 3—Areas with a lower infiltration rate that makes the area much less suitable for an artificial recharge program managed by a local water agency. These areas may be subject to a lower degree of monitoring and management of potential contaminating activities.

[Add intro language on DWSAP1996 amendments added by Safe Drinking Water Act]

The Drinking Water Source Assessment Program (DWSAP) defines areas of protection for individual wells. The program can easily be expanded to include larger areas within the watershed. While the DWSAP requires assessment of these issues, - amendments to the Clean Water Act do not require implementation of a protection program.

[Insert introduction of the following paragraph and provide context and significance. Break up the following paragraph into smaller paragraphs and add more info]

Other Methods of Enhancing Recharge

Two other methods of enhancing recharge and reducing runoff are flood water retention basins and reduced hardscape.

In the first half of the 20th century the U.S. Army Corps of Engineers, in conjunction with local flood control agencies, built detention dams in the canyons at the foot of southern California mountain ranges. The purpose of these detention dams was three-fold. First, when storms dropped large amounts of water high in the mountains the dams stopped the uncontrolled rush of the resulting frog chokers into downstream residential areas. Second, some of the water stored behind the detention dam infiltrated into the coarse sediment in the bottom of the detention area and recharged the local aquifer. And third, the dam was designed to release a smaller amount of water into the flood control channels and streams so that the water would not cause damage downstream. Many of these facilities are still functioning and some provide significant recreational opportunities during the dry season.

In the last half of the 20th century a different type of detention basin has been built in a number of urban areas. These detention basins, excavated so that they are lower than the surrounding land surface, serve as grass-covered parks during most of the year. During the winter they can fill with runoff from storms. Again, their purpose is three-fold. First they are used as recreational facilities during the non-storm season. Second they fill with storm runoff during the wet season, thereby reducing flood risk. And third, some or all of the water stored in these basins during the wet season recharges the local unconfined aquifer, while some of these basins may be located in the recharge area for a confined aquifer. In any such operation using urban runoff, adequate control must be exercised to prevent contamination of the aquifer by petroleum products and other urban contaminants.

A third method to increase recharge and reduce runoff is being implemented by TreePeople, a citizens' organization. TreePeople has been working with local government to retrofit playgrounds, school grounds, parking lots, and other parcels of land, to collect, treat, and funnel storm water to "dry" wells or other small scale infiltration facilities. Such wells are called Class V injection wells. While the goal of TreePeople is to reduce hardscapes and reduce runoff, the use of dry wells for disposal of the urban runoff can affect groundwater quality. To avoid contamination of the aquifer, certain best management practices are recommended. Those best management practices include: low-flow basins for runoff from industrial areas and other areas that could provide a high level of chemical contamination: pre-treatment for runoff: monitoring of water quality: evaluation of the data: and corrective action as necessary.

TreePeople has a very helpful web site at http://www.treepeople.org/. They have also published a report about their program to reduce urban runoff, *Rainwater as a Resource: A Report on Three Sites Demonstrating Sustainable Stormwater Management*. 2007

California's 58 counties are required by the California Water Code to regulate any type of water-related well, including injection wells, but the effectiveness of that program varies considerably depending upon the county. Class V injection wells are further regulated for groundwater quality purposes by the US Environmental Protection Agency in accordance with the Underground Injection Control program authorized by the Safe Drinking Water Act.

Potential Benefits of Recharge Areas Protection

The primary benefit of protecting recharge areas is that those recharge areas can be used by water managers to store water in aquifers as part of a program to provide a sustainable and reliable water supply of good quality. In some cases diversion of flood water to recharge facilities may benefit both flood control efforts and maintenance of a local water supply. The availability of a sustainable and reliable water supply may lessen the need to purchase alternative water supplies at greater expense. Protection of recharge areas does not make a water supply available: a supply of water to recharge the aquifer depends on coordination of regional and local governments and water management agencies.

Additional benefits of recharging groundwater include some removal of microbes and chemicals while the water moves through the unsaturated zone to the saturated zone, an increase in the amount of groundwater in storage that can later be extracted for local use or for export, and in some cases, use of the aquifer itself as the conveyance system from the recharge area to the point of extraction and use. In some cities, recharge basins are combined with flood control basins to reduce the amount of urban runoff. However, this practice may introduce contaminants, especially hydrocarbons, into the aquifer.

Existing Protection Efforts and Examples

[Insert a detailed description of existing program in place and the responsible agencies and interested parties. Basically to summarize what is now in place and how it is designed to work]

[Note: CDPH can put this together.]

The following are examples of steps that have been taken by local agencies to protect recharge areas:

1. List any known examples or efforts with some specific examples to the extent any information is available.

Potential Costs of Recharge Areas Protection

Some of the costs that may be associated with protecting recharge areas are:

- Purchase or lease price of the land that is to be used for a recharge area.
- Design and construction of facilities
- Land that is reserved for recharge areas cannot be used for other purposes that might provide a significant income for the landowner and tax revenues for the government
- If a local government agency owns the land, there is no tax income for the county

By not protecting recharge areas, water supply can be lost. The growth of urban areas, with roads, freeways, parking lots, and large warehouse type buildings, means that many areas no longer allow runoff to infiltrate into the ground. Instead, the runoff flows rapidly into streams which peak more quickly and at higher flow rates than before the urban facilities were built. This runoff may create flood flows and is lost to groundwater recharge and may require the expense of other facilities to provide a substitute for that lost recharge. In a few urban areas, injection wells have been built to take the place of recharge areas that were lost to urban development. Injection wells are expensive, require careful technical control, and are not always successful, but they may be cost effective in the face of the high cost of urban land in many cities.

Many potentially contaminating activities have routinely been allowed in recharge areas and contaminants have been carried into the aquifers. Because groundwater processes and the potential for contamination are not well understood by the public, many of these practices continue today. Remediation of contaminated aquifers can take decades, costs millions or billions of dollars, and remediation will never remove the contaminant completely from the aquifer. In such cases, the extracted groundwater must be treated at the wellhead at significant expense before it is suitable for potable and other uses.

A lack of protection of recharge areas could decrease the availability of usable groundwater. Recent studies by the US Geological Survey show contaminants present in recharge areas for aquifers in the Los Angeles area. Because of the low velocity of groundwater movement through the aquifer, contamination that occurs today may not arrive at down-gradient wells for 10 years or longer. In 10, 20, or 40 years, those contaminants will have been transported with the water flowing into the aquifer and the groundwater may require treatment before it can be used, thereby increasing the cost of water to the users. Protection of recharge areas now will help to prevent costs from escalating astronomically in the future. Because of the low velocity of groundwater movement through the aquifer, contamination that occurs today may not arrive at down-gradient wells for 10 years or longer. If we protect recharge areas by retaining those areas for recharge and by preventing contamination today, we are reducing future costs. Restoration of recharge areas will also hel to keep future costs lower.

Major Issues Facing Recharge Areas Protection

[Comment on the recent actions of DPH and SWB relative to the quality of recharge water.]

[There are requirements for groundwater recharge with recycled water and CDPH is developing specific regulations for groundwater recharge] [Groundwater recharge projects require monitoring wells]

Zoning

Zoning can play a major role in recharge areas protection by amending land-use practices so that existing recharge sites are retained as recharge areas. Some areas that would provide good rates of recharge have been paved over or built upon and are no longer available to recharge the aquifer. Local governments often lack a clear understanding of recharge areas and the need to protect those areas from development or contamination. Land use zoning staff does not always recognize the need for recharge area protection for water quantity and water quality.

Vector and Odor Issues

Standing water in recharge ponds or spreading basins is an attraction for mosquitoes, dragonflies, and other insects whose egg, larval, and pupal stages mature underwater. Dragonflies eat insects they catch on the fly, but mosquitoes can be vectors for a number of serious or deadly diseases. Existing recharge programs use large numbers of “mosquito” fish which feed on the mosquito larvae in the water. Odors can be generated by growth and decay of algae and other water-borne vegetation. Both vectors and odors must be addressed in any recharge program that involves standing water.

Potential Impacts

Protection of recharge areas can remove land from availability for other uses.

Recommendations to Promote Protection of Recharge Areas

The State can help promote additional protection of recharge areas by acting on the following recommendations:

1. Increase State funding for proposals to identify and protect recharge areas including incentives for the location and proper destruction of abandoned water wells, monitoring

wells, cathodic protection wells and other wells that could become vertical conduits for contamination of the aquifer. Provide funding and staff for Department of Public Health to initiate a program that would provide guidance and funding for local governments and agencies to implement source water protection measures that are logical outgrowths of the Drinking Water Source Assessment Program.

2. Expand research into surface spreading as a means of groundwater recharge and the fate of chemicals and microbes contained in the recharge water.

3. Develop a statewide program to identify actual and potential recharge areas throughout the state and provide that information to city and county governments.

4. Amend State law to prohibit local decision-makers from developing land for other purposes until it is known if that land is needed for recharge as a part of the local agency's groundwater management program.

5. Engage the public in an active dialogue using a value-based decision-making model in planning land use decisions that involve recharge areas.

6. Adopt a State-sponsored media campaign to increase public awareness and knowledge of groundwater and the importance of recharge areas.

7. Establish a "Water" element in the General Plan process that specifically requires a discussion by local government of the cost and values of protecting recharge areas versus the cost of non-protection. Eminent domain should not be allowed to convert potential recharge areas to other uses.[1]

8. Ensure that federal and State programs regulating subsurface disposal in accordance with the Safe Drinking Water Act's Underground Injection Control program and the California Clean Water Act's waste discharge requirements are fully funded and staffed.

9. Require local governments to provide protection of recharge areas for aquifers that have been identified as "sole source aquifers" pursuant to the Safe Drinking Water Act of 1974 (P.L. 93-523) and Amendments.

10. Develop educational programs for public works officials and other officials of local agencies and governments that will allow them to develop programs that realistically deal with the interaction of groundwater, surface water, storm water, recycled water, other surface flows, and the affect of contaminants in surface flows on contaminant levels in the aquifers.

11. Require that source water protection plans include an element that addresses recharge areas if groundwater is a part of the supply.

12. Convene a statewide panel to recommend changes to public schools and higher education curricula relating to groundwater. Encourage an integrated academic program on one or more campuses for protection of groundwater quantity and quality and why recharge areas are critical components.

[1] For a fuller discussion of the proposed water element in a General Plan, please refer to "Planning for a Demanding Water Future: The Legal Requirements for Long-Term Land Use and Water Planning in California, and an Analysis of a Water Element in the General Plan as a Means to Improve the Connection," found in Volume 4.

13. Develop a uniform method for analyzing the economic benefits and cost of recharge areas and provide guidance and assistance for economic feasibility analyses that could be used by project planners and funding agencies to assess recharge areas as compared with long-term reduction of water supplies, wellhead treatment, or injection wells.

14. Develop a signage program, modeled on such programs in other states, to notify people that they are entering an area of critical recharge for the groundwater they use daily, and that improper disposal of wastes can contaminate their drinking water.

Selected References

Web sites

California Department of Public Health: www.cdph.ca.gov

California State Water Resources Control Board: www.waterboards.ca.gov/gama

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Box x Terminology

Some terms that are used in discussing recharge are defined below. The definitions are taken primarily from DWR Bulletin 118-2003, *California's Groundwater.*

Abandoned well—wells that are abandoned but that have not been properly destroyed provide a vertical conduit for contamination of the aquifer. While there is no accurate count of the number of such abandoned wells in California, one estimate is that there are more than 1 million such wells that are potential vertical conduits for contamination of the aquifer. State law (Health and Safety Code § 115700) requires that such wells be destroyed. Some local jurisdictions require the old well to be destroyed before a permit is issued for construction of a new well.

Aquifer—a body of rock or sediment that is sufficiently porous and permeable to store, transmit, and yield significant or economic quantities of groundwater of good quality to wells and springs

Unconfined aquifer—an aquifer that is not bounded on top by an aquitard. The upper surface of an unconfined aquifer is the water table.

Confined aquifer—a body of rock or sediment bounded on top by an aquitard and containing groundwater that is under greater than hydrostatic pressure; that is, an artesian aquifer. When a confined aquifer is penetrated by a well, the water level will rise above the top of the aquifer

Aquitard—a confining bed, composed of rock or sediment that retards but does not prevent the flow of water to or from an adjacent aquifer. The movement of groundwater in an aquitard is exceedingly slow (very low permeability) and it does not yield water readily to wells or springs, even though it stores groundwater

Artificial recharge—the addition of water to a groundwater reservoir or aquifer by human activity, such as putting surface water into constructed spreading basins, allowing surface water to flow in strategically located unlined watercourses and ditches, or injecting water through wells.

Intentional recharge—sometimes used in place of 'artificial recharge'

Managed recharge—sometimes used in place of 'artificial recharge'

Deep percolation—percolation of water through the ground and beyond the lower limit of the root zone of plants into groundwater. Efficient agricultural and urban irrigation practices limit or eliminate deep percolation.

Natural recharge—recharge of an aquifer that occurs without human interference

Unintentional recharge—analogous to natural recharge

Recharge area—an area where surface water infiltrates into the ground and reaches a saturated zone in either an unconfined aquifer or a confined aquifer

The recharge area for an unconfined aquifer is the ground surface above the aquifer. The recharge area for a confined aquifer is always some distance away from the area where wells have been built that extract groundwater from the aquifer. In at least one case in California a water district overlies a confined aquifer, but the recharge area for the aquifer lies many miles outside the district's boundaries. In other cases recharge of the confined aquifer may occur only where a stream has eroded through the aquitard into the confined aquifer, allowing recharge to occur through the stream bottom.

Discharge area—an area where the groundwater that has been recharged flows out of the aquifer under natural conditions or is removed from the aquifer by wells. In general terms, the Earth consists of recharge areas and discharge areas, which may be either very close together (within meters), or very far apart (many kilometers).

<u>Recharge areas protection</u>—the title of this resource management strategy includes consideration of the following topics:

- Identification of potential recharge areas that should be protected so that
  - Recharge quantity can be maximized
  - Water quality is not contaminated
- Preservation of good recharge areas
- Limiting development and road-building in good recharge areas
- Land use practices that preserve good recharge areas
- Limiting land use practices that are potentially contaminating activities (See Department of Public Health's Drinking Water Source Assessment Program)
- Helping the public understand the need for protection of recharge areas from development and contamination
- Local government involvement in protecting recharge areas
- Protection of existing facilities, planning for future facilities, and enhancement of recharge quantity and quality
- Restoration of areas so that natural and artificial recharge will take place

<u>Restored recharge area</u>—describes some small basins, usually in the mountains, that have been reclaimed from activities that caused severe erosion and vegetation loss and that are now viable storage sites for groundwater that is released throughout most of the year into the watercourse