Runoff water monitoring at Dove Canyon Country Club

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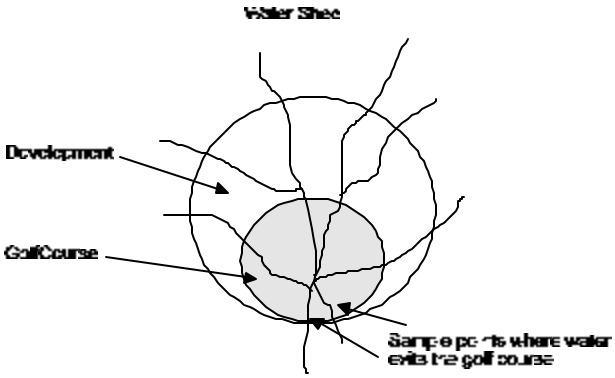
SUMMARY: Irrigation water and runoff water was monitored for three years at Dove Canyon Country Club to evaluate the impact of the golf course on down-stream water quality. When compared to the reclaimed irrigation water used throughout the development and the golf course, the runoff water was significantly lower in nitrates, total phosphorous, and total organic halogens. Oil and grease, total organic carbon, pH, and electrical conductivity of the runoff water were significantly higher than the irrigation water. There was no significant difference in the concentration of ammonia, nitrites, total Kjeldahl nitrogen in the irrigation and runoff waters. These results support the value of turfgrasses in capturing nitrogen and phosphorous, two key nutrients that can lead to eutrophication of waterways. The origin of the oil and grease, organic carbon, elevated pH and inceased salinity may be the golf course or the surrounding community that also drains into the same streams.

Background: The water shed surrounding the Dove Canyon Country Club and development drains into an Audobon preserve. In order to be sure the golf course operation was not negatively impacting runoff water, a runoff water monitoring study was initiated in 1992 and was terminated in early 1996.

There are several unique considerations that need to be described when assessing the Dove Canyon system. First, the irrigation water source is reclaimed from the surrounding region. There is no "fresh" water used to irrigate the Dove Canyon golf course. Second, the golf course has no control over the use of water, pesticides, houshold cleaning agents or other materials that might wash into storm drains from the housing development surrounding the golf course. The figure below illustrates the type of encountered at Dove Canyon and similar developments.



Materials and Methods: Sampling was carried out on an approximately monthly basis. A composit sample was collected from two streams exiting the golf course to represent th runoff water. A single grab sample was collected from a tee irrigation head to represent the reclaimed irrigation water. Samples were cooled and shipped with ice overnight to Brookside Laboratories. Analyses were conducted by the Environmental Division, Brooskide Laboratories, New Knoxville, OH using EPA approved protocols. The remainder of this report will provide descriptions of each factor and the analytical results from irrigation and runoff water analyses.

Results: A summary of minimum, maximum and average values for each factor measured is listed in Table 1. In addition, graphs have been provided to illustrate changes in each factor over time.

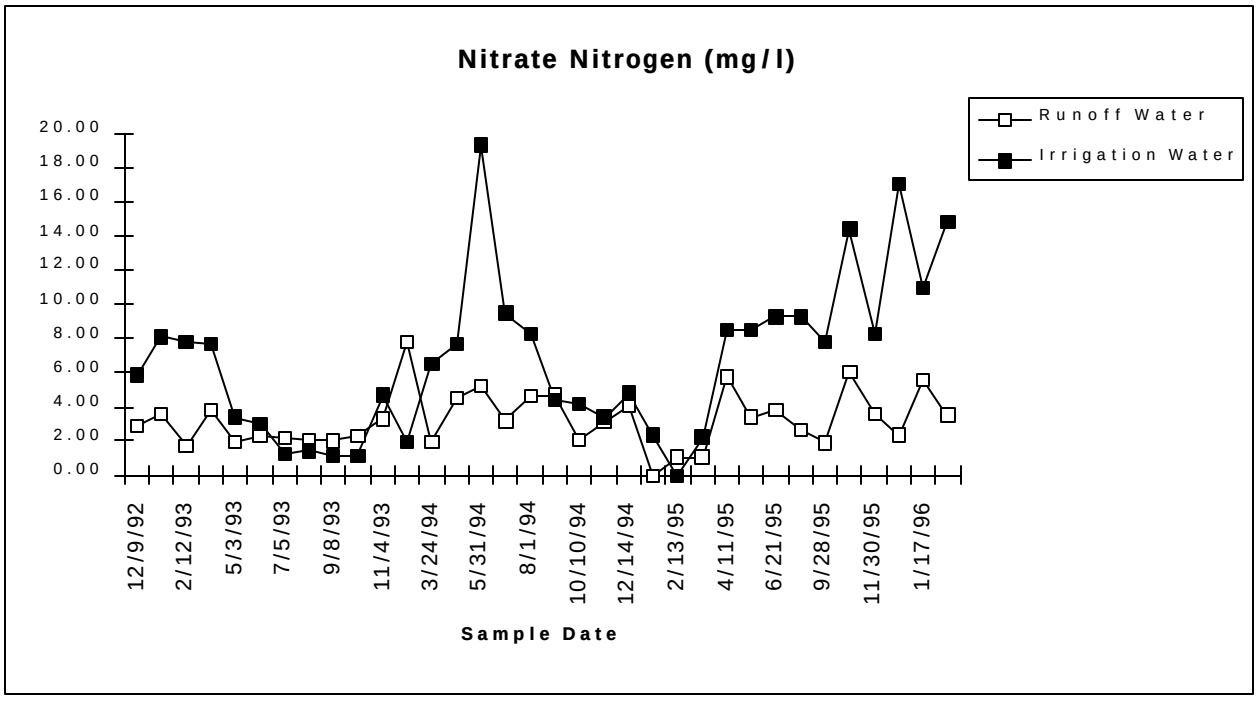
Seasonal variation in the values results from differences in rainfall, mountain snow melt and runoff into the water shed during the winter and early spring followed by droughty periods in the summer when a larger proportion of the stream water flow results from urban runoff.

Table 1. Summary thirty-four runoff and irrigation water samples collected over the course of three years. Values are in mg/l for all factors with the exception of pH which is in standard units and EC which is measured in umhos/cm. Abbreviations: O & G = oil and grease; TOC = total organic carbon; TOX = total organic halogens; EC = electrical conductivity.

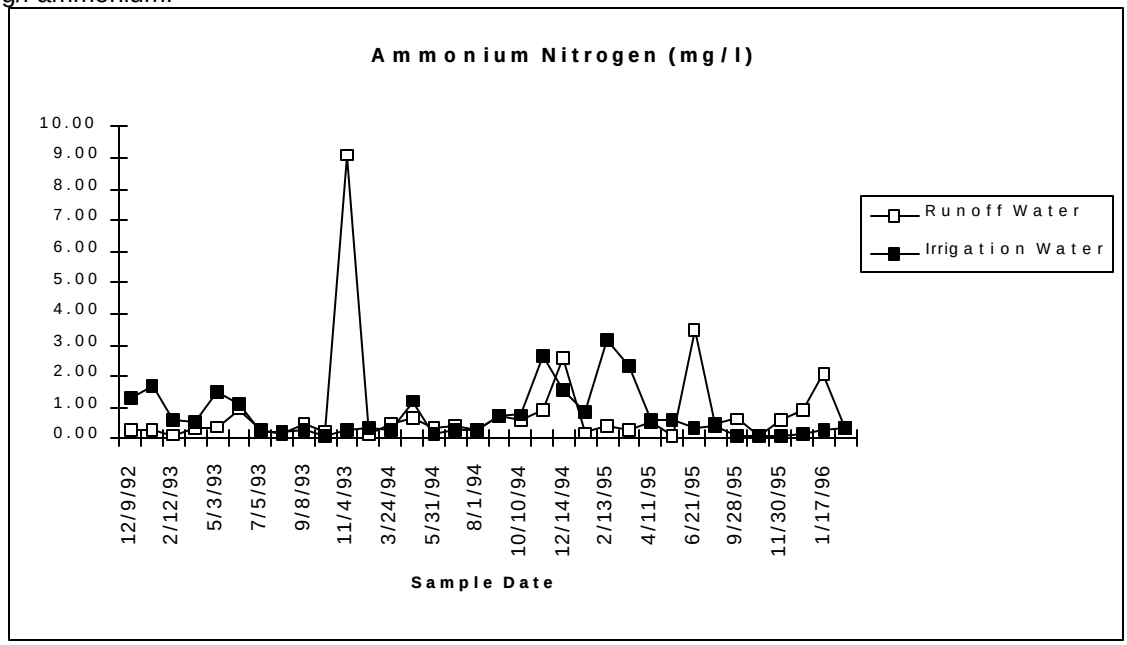
	Runoff Water			Irrigation Water			
Factor	Miniumum	Maximum	Average	Miniumum	Maximum	Average	P[1]
NO3	1.08	7.8	3.33	1.15	19.30	6.93	0.000
NH4	0.07	9.1	0.87	0.08	3.19	0.77	0.742
NO2	0.01	0.20	0.08	0.01	0.66	0.13	0.074
Total N	0.50	37.00	4.08	0.47	10.00	2.93	0.322
O & G	0.59	37.00	2.09	0.50	4.00	1.35	0.032
Total P	0.23	4.50	1.20	0.64	4.94	2.77	0.000
TOC	4.80	40.60	14.22	4.10	21.10	8.57	0.000
TOX	0.5	0.23	0.12	0.08	0.70	0.20	0.002
pH	7.28	8.48	7.72	6.89	8.06	7.43	0.000
EC	553	2250	1571	1068	1850	1293	0.001

[1] P refers to the probablility that the average values for runoff and irrigation water samples are the same. Values of less than 0.05 are considered statistically different by LSD test.

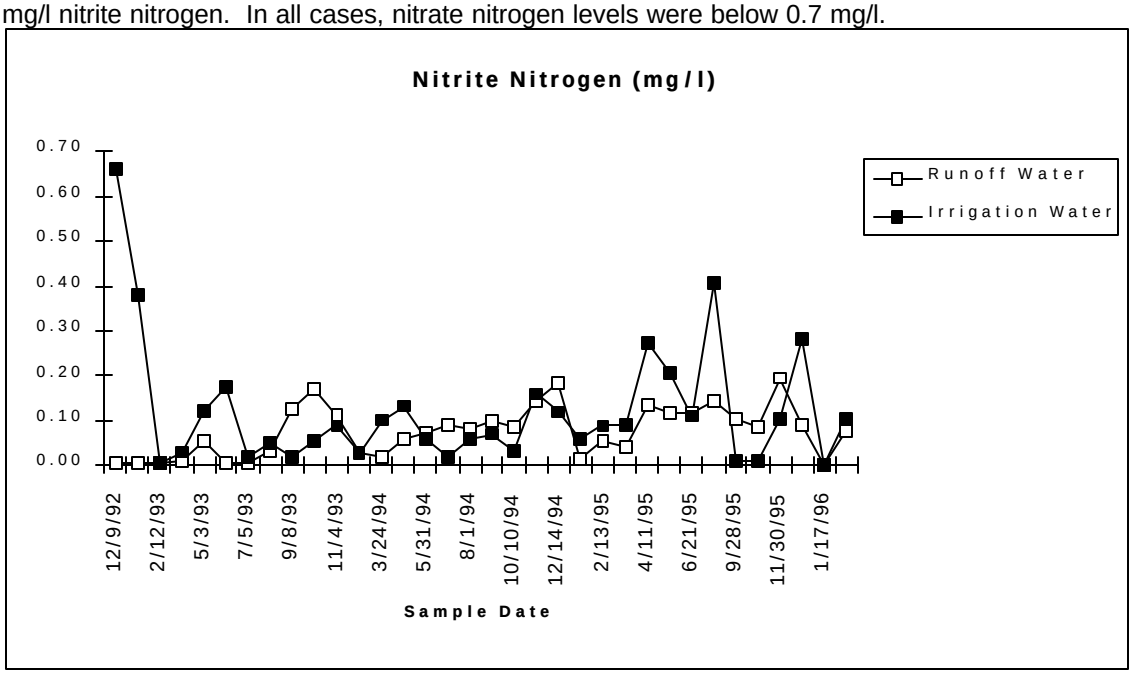
NITRATE NITROGEN: Nitrate (NO_3) nitrogen is a water contaminant that has minimum contamination levels for drinking water established at 10 mg/l. Untreated municipal wastewater frequently contains less than 1 mg/l nitrate nitrogen (Pettygrove and Asano, 1985). The runoff water never exceeded the 10 mg/l nitrate nitrogen threshold. The irrigation water, however surpassed this level on several sampling dates.



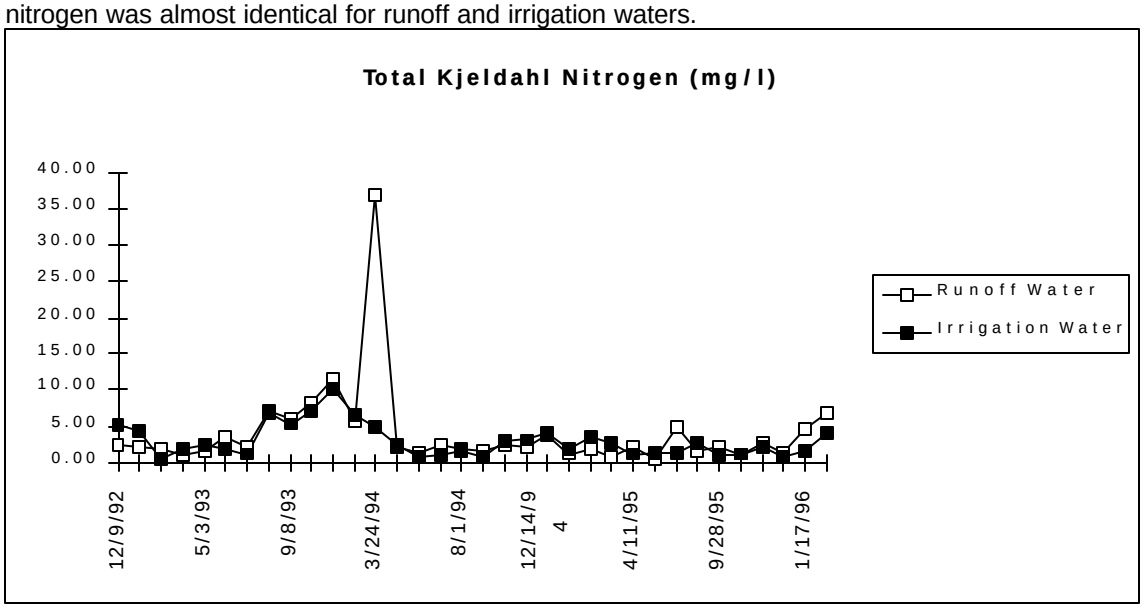
AMMONIUM NITROGEN: Ammonium nitrogen levels average 20 mg/l in untreated municipal wastewater. Secondary effluent from Santa Rosa West College, Napa Sanitation District, the American Canyon County Water District and the City of Davis contained 11, 1.5, 6.1 and 8 mg/l ammonium nitrogen respectively (Pettygrove and Asano, 1985). In most cases, the ammonium nitrogen content of both the runoff and irrigation waters were below 5 mg/l. On one occassion (11/4/93), the runoff water sample reported almost 10 mg/l ammonium.



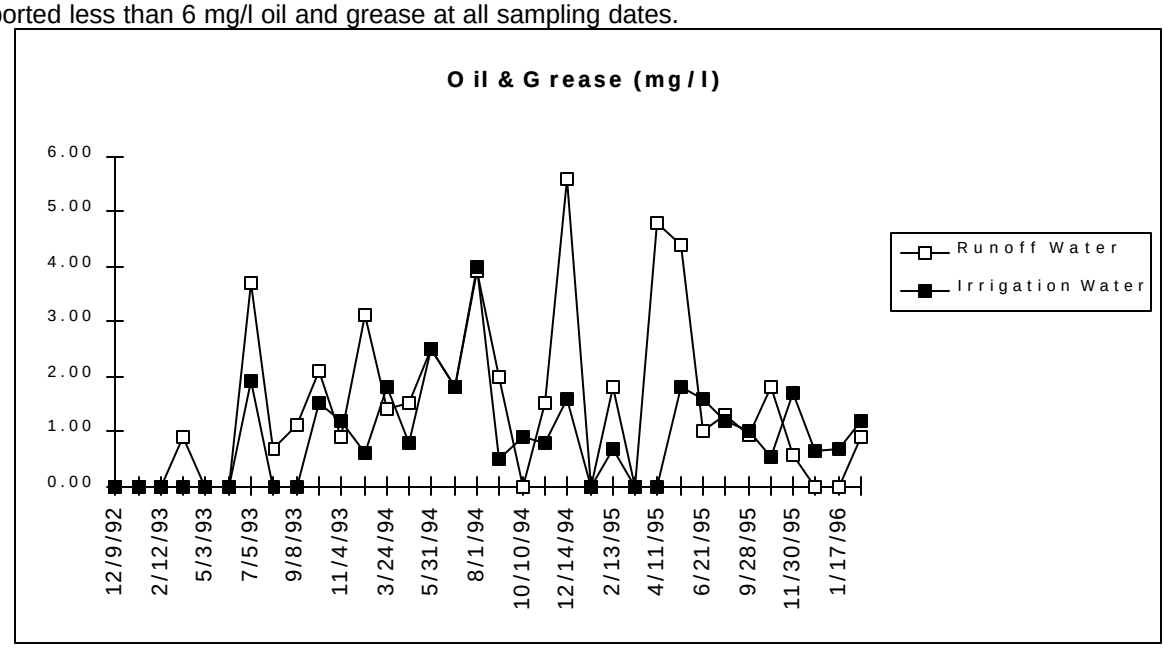
NITRITE NITROGEN: Untreated municipal wastewater nitrite (NO_2) nitrogen levels average 0.6 mg/l . Secondary effluent from Santa Rosa West College, Napa Sanitation District, the American Canyon County Water District and the City of Davis contained 0.7, 2.2, 1.2, and 1.0 mg/l nitrite nitrogen respectively (Pettygrove and Asano, 1985). In most cases, both the irrigation water and runoff waters reported less than 0.50 mg/l nitrite nitrogen. In all cases, nitrate nitrogen levels were below 0.7 mg/l.



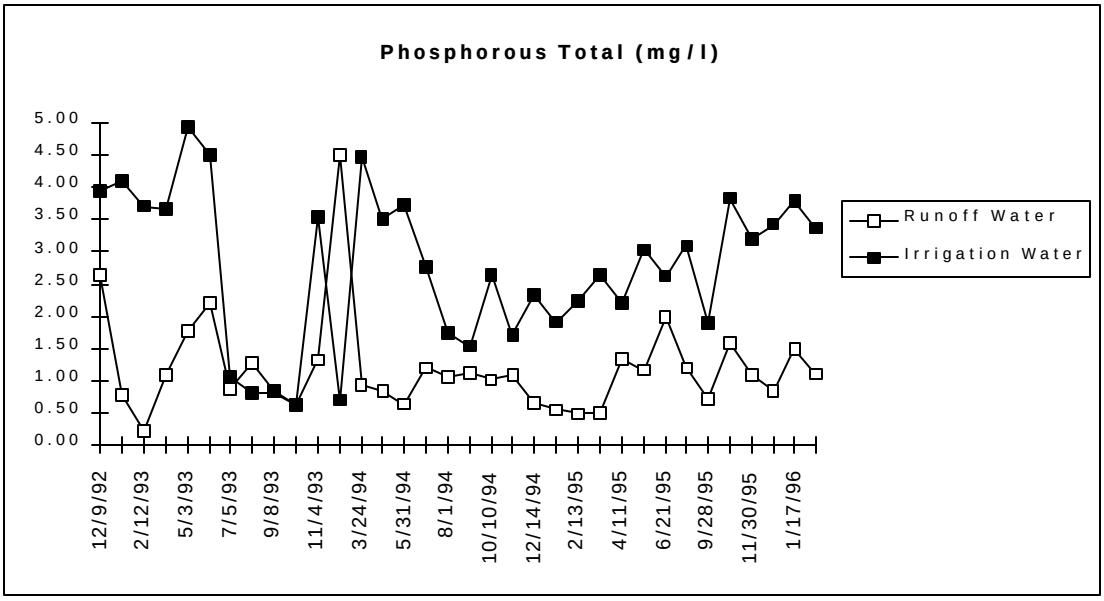
TOTAL KJELDAHL NITROGEN: Total nitrogen levels average 34 mg/l in untreated municipal wastewater. Secondary effluent from Napa Sanitation District, the American Canyon County Water District and the City of Davis contained 14.4, 18.3 and 13 mg/l total nitrogen respectively (Pettygrove and Asano, 1985). On one occassion (3/24/94), total Kjeldahl nitrogen reached 37 mg/l in the runoff water. At all other sample dates, total nitrogen was almost identical for runoff and irrigation waters.



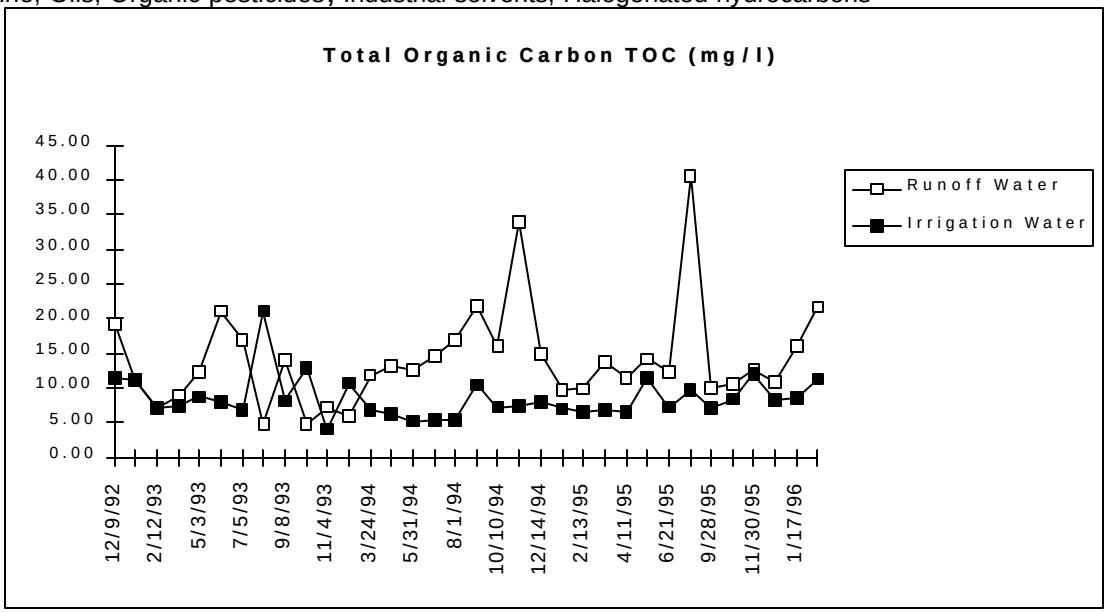
OIL AND GREASE: Grease contamination ranges from 50-150 mg/l in untreated wastewater. Secondary effluent from Napa Sanitation District and the American Canyon County Water District contained 9.0 and 7.0 mg/l oil and grease respectively (Pettygrove and Asano, 1985). Both the runoff water and irrigation water reported less than 6 mg/l oil and grease at all sampling dates.



TOTAL PHOSPHOROUS: Total phosphorous levels average 9.4 mg/l in untreated municipal wastewater. The typical phosphate pickup resulting from domestic water use is 5 to 15 mg/l. Secondary effluent from Santa Rosa West College, Napa Sanitation District and the American Canyon County Water District contained 17, 5.5, and 8.6 mg/l phosphate respectively (Pettygrove and Asano, 1985). In all cases total phosphorous was less than 5 mg/l with the irrigation water most frequently being higher in phosphorous than the runoff water.



TOTAL ORGANIC CARBON (TOC): The TOC screen detects a variety of pollutants. They include: Gasoline, Oils, Organic pesticides**,** Industrial solvents, Halogenated hydrocarbons



To compare TOC values, untreated municipal wastewater contains on the average 102 mg/l TOC. The city of Davis reported untreated wastewater at 64 mg/l TOC, primary effluent at 40.6 mg/l TOC and secondary effluent at 19.8 mg/l TOC. Therefore, a TOC value of 40 mg/l or below is about equivalent to a primary treated effluent water (Pettygrove and Asano, 1985). The TOC values of the runoff water was consistently higher than the irrigation water. In one case the runoff water exceeded 40 mg/l that is typical for a primary treated effluent water.

TOTAL ORGANIC HALOGEN (TOX) SCREEN: The TOX screen is designed to detect organic chemicals that contain chlorine, bromine, iodine, and fluorine (halides). These chemicals are found in pesticides and solvents commonly used in agriculture. Because there are hundreds of organic halides in use by various sectors of our society, and the cost of testing for each compound would be prohibitive (more than $45/compound), a screening test was developed to detect the organic halogens as a group. When no organic halogens are found, it is likely that there is extremely minute or no halogenated chemicals in the water. If organic halogens are found at levels above 100 ug/l, further evaluation may be needed. The following list contains some of the chemicals that are detected in the TOX test. The list is not comprehensive but contains many commonly used materials.

Aatrex-Atrazine
Aldrin
Balan-Balfin
Basalin
Captan
2,4-D
Dieldrin
Dual
Karmex-Karmex DL
Lasso
Lorox
Methoxychlor
Milogard
Princep
Propachlor
Propazine
Simazine
Sinbar-Terbacil
Telvar-Monuron
Tolban
2,4,5-TP (Silvex)
Treflan-Trifluralin
Trithion
Bromodichloromethane
Bromomethane
Carbon tetrachloride
Chlorobenzene
Chloroethane
2-Chloroethylvinyl Ether
Chloroform
Chloromethane
Dibromochloromethane
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,3-Dichlorobenzene
Dichlorodifluoromethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethene
Trans-1,2, Dichloroethene
1,2-Dichloropropane
cis-1,3-Dichloropropene
Methylene chloride
1,1,2,2-Tetrachloroethane
Tetrachloroethene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethene
Trichlorofluoromethane
Vinyl chloride
Chlorobenzene
Ethylbenzene
4-Chloro-3-Methylphenol
2-Chlorophenol
2,4-Dichlorophenol
Pentachlorophenol
2,4,6-Trichlorophenol
Aldrin
a-BHC
b-BHC
c-BHC
g-BHC
Chlordane
4,4'-DDD
4,4'-DDE
4,4'-DDT
Dieldrin
Endosulfan I
Endosulfan II
Endosulfan Sulfate
Endrin
Endrin Aldehyde
Heptachlor
Heptachlor Epoxide
Toxaphene
PCB-1016 (Arochlor 1016)
PCB-1221 (Arochlor 1221)
PCB-1232 (Arochlor 1232)
PCB-1242 (Arochlor 1242)
PCB-1248 (Arochlor 1248)
PCB-1254 (Arochlor 1254)
PCB-1260 (Arochlor 1260)
Bis-(2-chloroethyl)-ether
Bis-(2-chloroethoxy)methane
Bis-(2-chloroisopropyl-ether
4-Bromophenyl phenyl ether
4-chlorophenyl phenyl ether
2-chloronapthalene
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocylopentadiene
Hexachloroethane
1,2,4-trichlorobenzene

If the total organic halogen (TOX) levels are above a maximum desired level, a series of additional tests are recommended. These tests were selected because there are maximum contaminant levels (MCL) or recommended maximum contaminant levels (RMCL) have been established for drinking water. These stringent levels are provided as guidelines only and each runoff water situation needs to be addressed on a case-by-case basis. The goal is, of course, to identify the sources of contamination and eliminate the source if possible. However, we do not expect to meet drinking water standards when the input water source is reclaimed water.

The additional tests that may be needed might be triggered as follows. If the TOX result indicates more than 10 ppb (µg/l), tests or vinyl chloride, carbon tetrachloride, 1,2-dichloroethane, 1,2-dichloropropane, trichloroethylene, 1,1-dichloroethylene and Lindane would be selected. If the TOX was 30 ppb, tests for the above chemicals would be selected in addition to, 2,4,5-TP, monochlorobenzene, and 2,4-D. To complement this method, a list of potential contaminants that may have been introduced at the site will aid in tracking down the source of the contamination.

Table 2. Maximum contaminant levels for some volatile organic chemicals.

Contaminant	MCL (ug/l)
Vinyl Chloride	1.1
Carbon Tetrachloride	4.6
1,2-Dichloroethane	3.6
Trichloroethylene	4.0
1,1-Dichloroethylene	5.1
1,1,1-Trichloroethane	159.4
p-Dichlorobenzene	36.2
TOX	540.0

Source: Fed Reg. 50:219 (Nov 13, 1985)

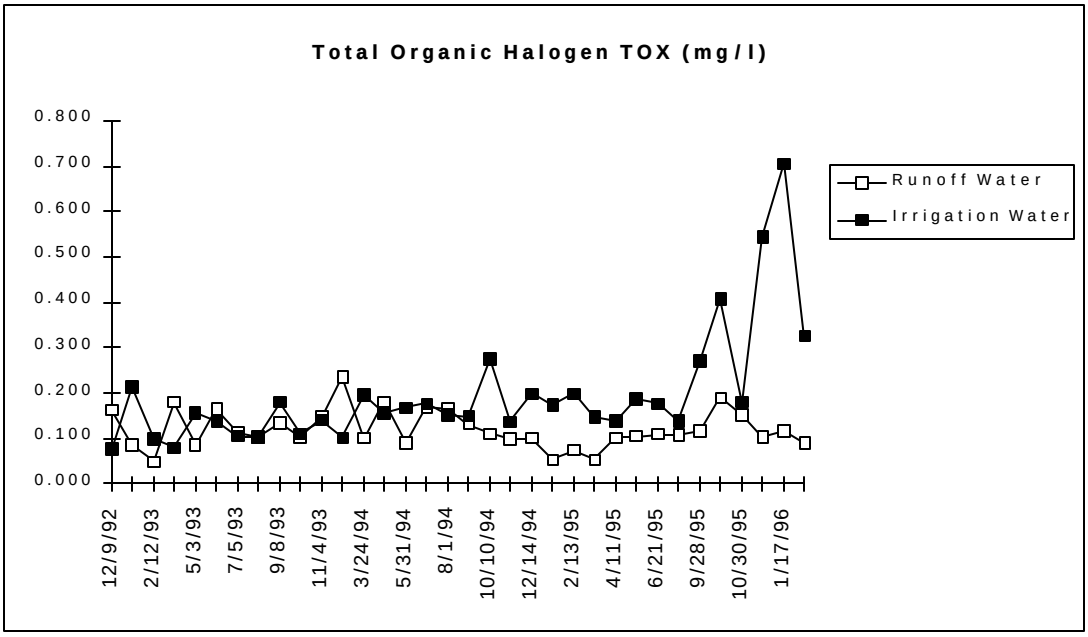
Table 3. Recommended Maximum Contaminant Levels (RMCL) for some synthetic organic chemicals.

Contaminant	MCL (ug/l)
Alachlor	0.0*
Chlordane	0.0
cis-1,2-Dichloroethylene	51.0
1,2-Dibromo-3-chloropropane (DBCP)	0.0
1,2-Dichloropropane	4.0
o-Dichlorobenzene	299.0
2,4-D	22.0
1,2-Dibromomethane (EDB)	0.0
Epichlorohydrin	0.0
Heptachlor	0.0
Heptachlor epoxide	0.0
Lindane	0.1
Methoxychlor	105.0
Monochlorobenzene	19.0
Pentachlorophenol	146.0
2,4,5-TP	22.0
Toxaphene	0.0
trans-1,2-Dichloroethylene	51.0
TOX	719.1

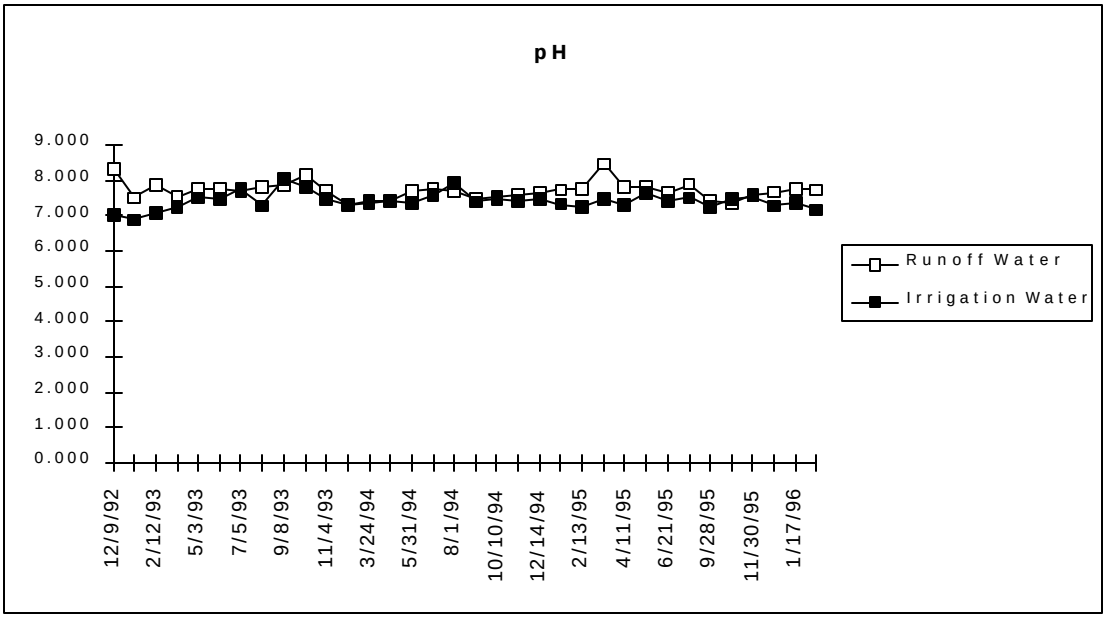
* limits listed as zero will not be set at zero but will be very low.

Source: Fed Reg. 50:219 (Nov 13, 1985)

The results below are reported in mg/l which is equivalent to 1000 ug/l. Therefore, a value of 0.100 mg/l is equivalent to 100 ug/l. In many cases, the TOX tests reported more than the drinking water limit of 100 ug/l. Additional tests were not conducted because the irrigation water generally reported higher TOX values than the runoff water.

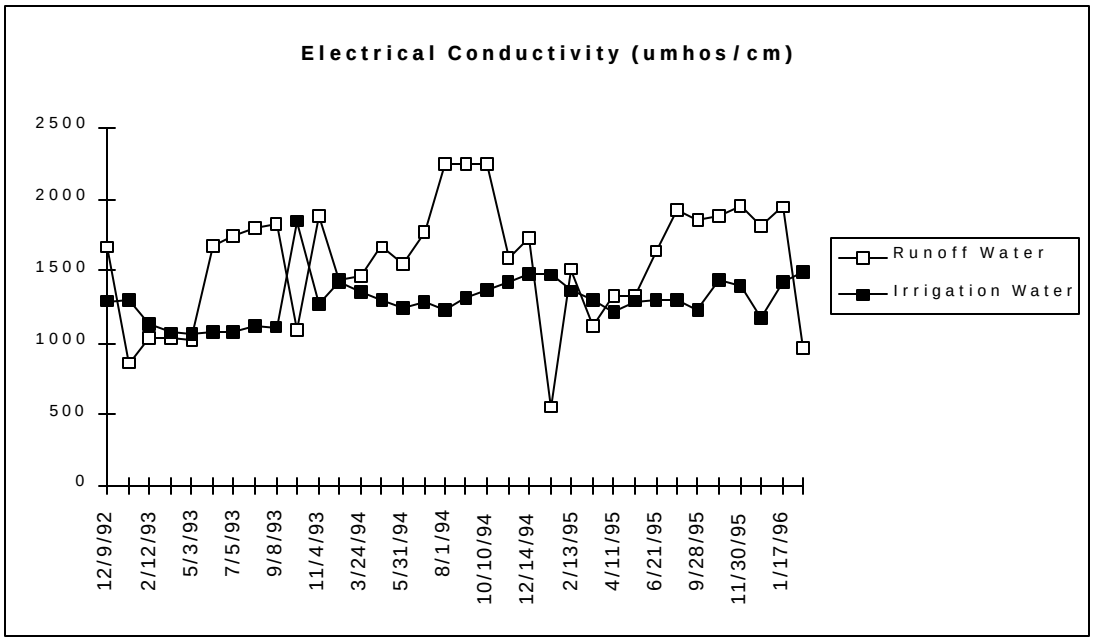


pH: The normal range of pH for municipal waste water is between 6.5 and 8.5. Therefore, the reclaimed irrigation water and runofff waters both fall within this expected range (Pettygrove and Asano, 1985).



Electrical Conductivity: The electrical conductivity (EC) of an irrigation water should be less than 700 umhos/cm (0.7 dS/m) to be used without restriction. Waters with ECs between 700 and 3000 umhos/cm can be used with caution and waters with ECs exceeding 3000 umhos/cm should not be used for irrigation.

Untreated municipal waste water from the Los Angeles County Joint Plant and from the City of Davis were 2185 and 2520 umhos/cm respectively. Primary effluent from Arroyo Grande, Santa Barbara and the City of Davis reported ECs of 2300, 2850, and 2340 umhos/cm respectively. Secondary effluent from Montecito Sanitary District reported an EC of 1390 umhos/cm. Advanced waste water treatment plants at Long Beach, Los Coyotes, Pamona, Dublin San Ramon, and the City of Livermore reported ECs of 1352, 1438, 1018, 1270, and 1250 umhos/cm respectively. The reclaimed irrigation water and runoff waters at Dove Canyon both fall within the acceptable range compared to these examples (Pettygrove and Asano, 1985). The runoff water clearly indicates that dissoved salts accumulate in the runoff water. The highest EC values in the runoff water correspond to the summer months when irrigation is used more heavily in the development and on the golf course.



References:

Pettygrove, G.S. and Asano, T. eds 1985. Irrigation with Reclaimed Municipal Wastewater-A Guidance Manual. Lewis Publishers, Chelsea, MI