Special Investigation:
Ditch 66: Pollution Source Inventory

In 1998, the Anoka Conservation District conducted a stream water quality assessment of the Rum River and its subwatersheds. This assessment concluded that the Ditch 66 subwatershed in Ramsey had the highest conductivity and chloride levels in the Lower Rum River Watershed. These two parameters suggest that there is considerable impact by human activity that may over time affect the outstanding water quality of the Rum River.

Based on the recommendations of that study, the Lower Rum River Watershed Management Organization (LRRWMO) contracted with the Anoka Conservation District (ACD) to examine water quality conditions and investigate possible pollution sources in the Ditch 66 subwatershed.

Methods

Water Quality Monitoring - In the spring and summer of 2001, ACD monitored Ditch 66 at multiple sites to identify the location of chloride sources. The primary monitoring site was the Ditch 66 at the crossing of Dysprosium Street in the City of Ramsey. This site was selected because it is at the bottom of the subwatershed and because the same site was monitored in 1998 and 2000, allowing historical comparisons. Four other sites monitored to determine chloride source locations were ditch crossings at 160th Lane, Wolfram, Nowthen, and Xenon Boulevards. Unfortunately, due to the dense riparian corridor, private property issues and the ditch's close interaction with wetlands, it was not possible to walk the stream corridor to identify small tributaries that could be a pollution source.

Conductivity, turbidity, pH, dissolved oxygen, temperature, salinity, total phosphorus, total suspended solids, chloride and stream stage measurements were recorded during ten monitoring events conducted during storm events (4) and base flow (6) conditions. Grab samples were analyzed for total phosphorus and total suspended solids (Dysporsium site only) and chlorides (all sites) at Braun Intertec. All other parameters were measured in the field with a hand-held multiprobe. Stream stage was measured using a stationary stream gage installed in the streambed. For an explanation of the water quality parameters measured, please see Chapter 1 of this Water Almanac.

Groundwater Monitoring - The ACD collected all available groundwater chloride data from EPA and USGS for use in evaluating non-point sources. EPA's STORET database contained very little groundwater chloride monitoring data for Minnesota. On the other hand, the USGS has completed chloride studies and their database had information from a monitoring well in the Ditch 66 subwatershed, though the information was from the 1980's.

Landcover Analysis -

Boundary Confirmation – Ditch 66 is fed by both groundwater and surface water runoff from the surrounding subwatershed before it empties to the Rum River. To define the area of investigation, the ACD started by verifying the boundary of the subwatershed. Any stream or groundwater outside of this boundary could not be contributing to Ditch 66. Upon request, the City of Ramsey provided the ACD with a map of the subwatershed boundary. Using topographic maps, ACD staff confirmed this boundary to be correct, and it became the base of all subsequent inventories and maps created for this investigation.

Subdivision Map Review – Since the landcover of the subwatershed is primarily single-family homes, this was the first landcover type to examine for chloride sources. Specifically, the ACD was interested in the layout of the housing developments and stormwater conveyances/ponding in proximity to the ditch. ACD staff compiled a list of all residential developments within the subwatershed and gathered the available maps of these areas from the City of Ramsey. Storm drainage plans were of particular interest, although these maps were not available for all residential developments. In these cases, a plat map was reviewed instead.

There were several residential developments for which no maps were available.

Neighborhood Inventory – ACD staff conducted a windshield survey of all the neighborhoods within the subwatershed to identify features affecting drainage and landuse practices or facilities, which might be contributing chloride to the ditch. Residential development maps were used to record topographic features within each neighborhood such as road elevations (i.e., high points and low points), stormwater control methods such as curb and gutter or roadside swales, structural features such as culverts, swales, flumes and natural features such as dominant vegetation and wetlands. For developments without plat maps, large aerial photos were used in the inventory process.

Since stormwater runoff was a very likely source of chloride, stormwater management methods were closely examined in the field. The ACD documented the type of stormwater management utilized along with topographic features such as high and low points on the road way. Although the topographic differences were fairly small, noting the high and low points indicated the direction of stormwater runoff. Culverts, grates and wetlands were also recorded to assess stormwater routing and retention/infiltration areas. These surveys confirmed and corrected any discrepancies on the drainage maps obtained from the City, and completed the picture of stormwater drainage throughout the entire area.

Landcover Inventory – The ACD conducted a GIS landcover inventory to locate landuse practices or facilities which may be contributing chloride to Ditch 66. Using aerial photos of the subwatershed, the landcover type was identified and classified using the Minnesota Land Cover Classification System developed by the Minnesota Department of Natural Resources. This data was analyzed with Arcview GIS software. Landcover types were field checked during the neighborhood windshield surveys.

GIS data for soils, depth to groundwater, wetlands, the time frame of residential development in the subwatershed and landuse were also analyzed. Historical and infrared photos supplemented the GIS analysis.

RESULTS

Water Quality Monitoring - In 2001, as in 1998 and 2000, chloride, conductivity, and salinity in Ditch 66 at Dysporsium Street were higher than the North Central Hardwood ecoregion mean and the Lower Rum River Watershed mean.

From the ten monitoring events conducted at the Dysprosium Street ditch crossing, the mean chloride concentration was 59 mg/l (Table 4-1). Over the course of the 2001 monitoring season, chloride levels remained fairly consistent regardless of rainfall (Fig. 4-1). The ACD found that statistically there was no difference in chloride levels during base flow and storm events (one-way ANOVA, $F= 0.41$, $p= 0.54$). Although slightly higher in 2001 than detected in 1998, chloride stayed relatively constant since monitoring began in 1998 (mean chloride values for 1998:50 mg/l and 2000: 46 mg/l).

At Dysprosium Street in 2001, the mean conductivity level was 0.6099 mS/cm. These conductivity levels followed the same pattern as chlorides from 1998 -2001 (Figure 4-2) and salinity concentrations were consistently at 0.2% throughout all monitoring activities at this site.

Additional water samples collected upstream of Dysprosium Street in July 2001, also detected higher than average chloride levels (Table 4-2) but did not reveal a particular source area. Chloride levels were consistent throughout the length of the stream except between Xenon Street and Nowthen Blvd (Figure 4-3). From this limited sample set, it appears that chloride concentrations were lower upstream of Nowthen Blvd. From the headwaters to Nowthen Blvd, the ditch meanders through an extensive system of wetlands. The lower concentration of chloride found in this area is likely due to a large open space where there is no development and only one road crossing. Nowthen Blvd is a major county road and downstream of this crossing the density of residential development increase, particularly in proximity to the ditch therefore increasing potential chloride inputs to the ditch. Samples could not be obtained from the ditch crossing at Ramsey Boulevard due to very shallow water conditions. Additional surface and groundwater sampling will be needed to determine relative trends in chloride levels throughout the ditch corridor.

Groundwater Monitoring – To evaluate the chloride from non-point sources, groundwater data was obtained from a USGS well in the Ditch 66 subwatershed. Groundwater samples were taken from a depth of 14 and 29 feet from the same well. The mean chloride concentration from both depths was 32 mg/l (n=5 for both depths). The maximum chloride concentration for the 14 ft depth was 77 mg/l in 1987 and 47 mg/l at the 29 ft depth in 1985.

Landcover Analysis – The landcover analysis component of this investigation covered the following areas: subwatershed and ditch characteristics, landuse, landcover, soil type, wetlands, and stormwater conveyances. Respective maps can be found in the appendices.

The Ditch 66 subwatershed drains an area of 2,929 acres in the central portion of the City of Ramsey. Located in the North Central Hardwood Forest ecoregion, the subwatershed primarily consists of single-family homes. Ditch 66 flows from just west of Ramsey Blvd eastward for approximately 4.25 miles to the Rum River. The ditch crosses under three major roads: Ramsey Blvd, Nowthen Blvd, and St. Francis Blvd. Ditch 66 is buffered on both sides by an extensive system of wetlands, particularly in the headwaters of the subwatershed. The stream ranges from 1 – 6 feet wide and is fairly shallow most of the year ranging from 3 inches to 12 inches in depth. In dry years, Ditch 66 is extremely shallow with little flow and has run dry.

Ditch 66 has been in existence since the early 1900’s when the land was being drained for farming. Aerial photos dating back to the 1930’s show this subwatershed was entirely cropped with the ditch having very little vegetative cover. In the late 1960’s, farmland was being converted to residential development and the riparian area of the ditch became reestablished. Most of the residential development, particularly in close proximity to the ditch, occurred between 1970 and 1980. Presently, 72% of the subwatershed is single family residential followed by wetland and forestlands with only 5% still being farmed.

In regard to commercial development and hazardous materials, there are two small strip malls, a gas station and cabinetry shop in a commercial area in the northern portion of the subwatershed just west of St. Francis Blvd at 167th Ave. This commercial area is located over ½ mile from the stream. There are four entities within the subwatershed that have small quantity generator permits. These permits are for small businesses or individuals generating less than 220 pounds of hazardous waste or less than 2.2 lbs of acute hazardous waste per month. No spills or incidents involving hazardous materials or chloride have been documented by the Minnesota Pollution Control Agency.

Currently, the ditch corridor is heavily vegetated and at times meanders through wetlands which made it very difficult to survey the stream on foot. Attempting to identify small tributaries contributing to the ditch was not possible due to the ditch’s strong interaction with the surrounding wetlands.

The Ditch 66 subwatershed is located outside of the municipal service boundary; all homes have individual sewage treatment systems (septic systems) and drinking water wells. From aerial photos and neighborhood surveys we found the majority of homes are at least 100 feet set back from the stream. Without onsite inspections and additional water quality monitoring, it is difficult to assess the possible contribution of chloride from septic systems to the ditch.

The majority of residential developments within the subwatershed (82 %) have roadside infiltration swales to control stormwater. Some neighborhoods have constructed ponds and utilize existing wetlands to manage stormwater. Of the twenty-eight neighborhoods in the subwatershed, only two have a curb and gutter system of stormwater management. Stormwater in these neighborhoods is directed to wetlands for infiltration.

The soils in this area are primarily of the Hubbard-Nymore association, which is nearly level to gently sloping, excessively drained soils that are sandy throughout. Seventy-one percent of the subwatershed is made up of soils that are upland, excessively drained soils with a depth to groundwater greater than six feet deep. These upland soils support the residential development within the subwatershed. The remaining 29% of the subwatershed soils have a depth to groundwater less than five feet deep. This area encompasses the ditch corridor and riparian area. Eighteen percent of the subwatershed is wetlands, which can be found along the ditch corridor. Nearly two-thirds of the wetlands are marsh wetlands providing considerable direct mixing of groundwater and Ditch 66.

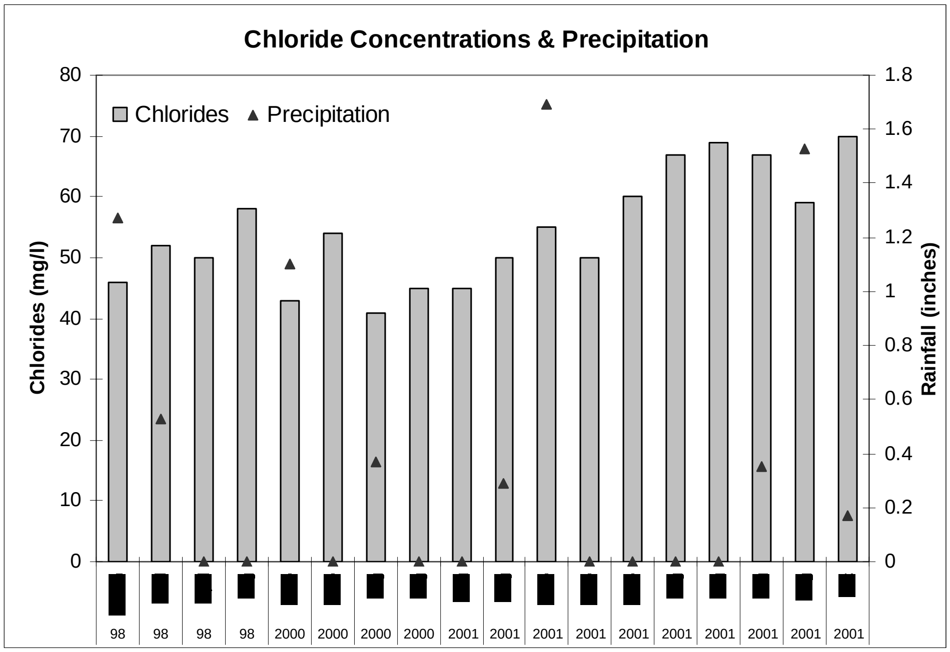

Figure 4-1. Ditch 66 at Dysprosium Street and precipitation.

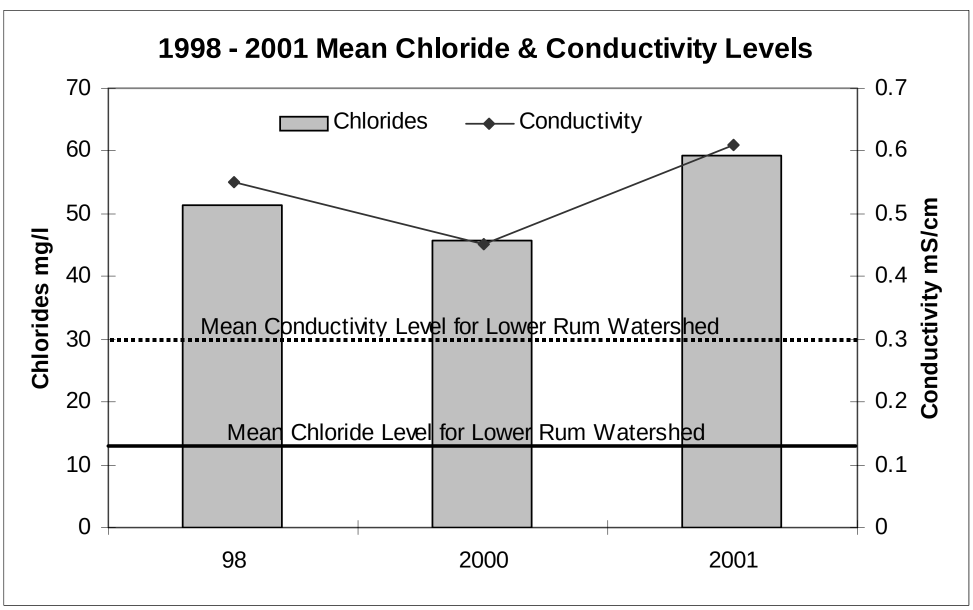

Figure 4-2. Ditch 66 chloride and conductivity levels over the past three monitoring seasons.

Table 4-1. Ditch 66 water quality results.

Dysprosium Street Crossing												
Event	Type	pH	Conductivity mS/cm	Turbidity NTU	DO mg/l	Temp C	Salinity %	Total Phosphorus mg/l	TSS mg/l	Chlorides mg/l	Precip Inches	Stage Inches
5/3/01	Baseflow	6.20	0.501	na*	11.62	13.7	0.02	0.040	< 10	45	0	0.74
5/22/01	Storm	6.80	0.578	1	9.41	10.1	0.02	0.040	8	50	0.29	0.68
6/11/01	Baseflow	5.98	0.628	1	6.65	15.3	0.02	0.068	3	55	1.69	0.58
6/19/01	Baseflow	7.36	0.580	1	n/a*	17.2	0.02	0.086	8	50	0	0.59
6/25/01	Baseflow	7.38	0.631	2.5	7.71	17.9	0.02	0.074	3.3	60	0	0.21
7/3/01	Baseflow	7.50	0.680	10	8.83	15.8	0.02	na**	na**	67	0	0.48
7/10/01	Baseflow	8.31	0.682	n/a*	8.17	17.3	0.02	0.064	< 5	69	0	0.40
7/23/01	Storm	8.57	0.647	n/a*	5.94	17.4	0.02	0.077	4	67	0.35	0.46
8/1/01	Storm	7.71	0.617	n/a*	5.12	20.3	0.02	0.099	12	59	1.53	0.53
10/10/01	Storm	8.30	0.555	n/a*	5.9	12.5	0.02	0.037	< 5	70	0.17	0.5
Min		5.98	0.501	1	5.12	10.1	0.02	0.037	5	45	0	0.21
Mean		**7.41**	**0.609**	**3.1**	**7.70**	**15.7**	**0.02**	**0.065**	**10.37**	**59**	**0.304**	**0.51**
Max		8.57	0.682	10	11.62	20.3	0.02	0.099	12	70	1.53	0.74
Lower Rum River Mean		**7.75**	**0.331**	**13.4**	**9.46**	**13.4**	**0.01**	**0.14**	**10**	**13.31**	**---**	**---**
NCHF Ecoregion Mean			**0.382**					**0.22**				

*The turbidity sensor and dissolved oxygen sensor on our multiprobe was malfunctioning which lead to the recalibration of the entire multiprobe.
**Samples were not obtained during this sampling round.

Table 4-2. Supplementary data from road crossings upstream of Dysprosium Street site.

Location	Event	Type	pH	Conductivity mS/cm	Turbidity NTU	DO mg/l	Temp C	Salinity %	TP mg/l	TSS mg/l	Cl mg/l
Ditch 66 at 160th Ln	7/3/2001	baseflow	7.05	0.681	na	9.81	16.7	0.02	---	---	64
Ditch 66 at Wolfram	7/3/2001	baseflow	6.73	0.744	na	3.22	16.9	0.03	---	---	83
	7/16/2001	baseflow	na*	na	na	na	na	na	---	---	92
Ditch 66 at Nowthen	7/16/2001	baseflow	na	na	na	na	na	na	---	---	85
Ditch 66 at Xenon	7/3/2001	baseflow	5.9	0.594	13	2.35	20.3	0.02	---	---	24
	7/16/2001	baseflow	na	na	na	na	na	na	---	---	60
Mean at Dysprosium-baseflow conditions			**7.12**	**0.617**	**3.62**	**8.59**	**16.02**	**0.02**	**0.0664**	**4.76**	**57.66**

*During this time period the hand held multiprobe was unavailable because it was being calibrated by the manufacturer. Water samples for chloride analysis were collected to be analyzed by Braun Intertec.

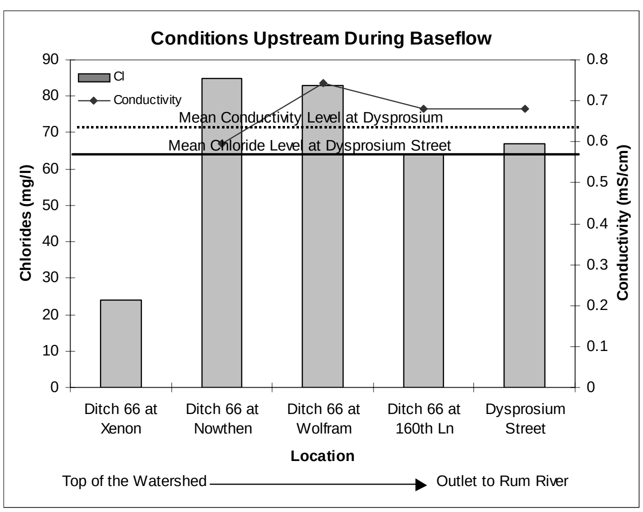

Figure 4-3. Chloride and conductivity conditions at ditch crossing upstream of Dysprosium Street.

DISCUSSION

In Minnesota, a water quality standard for chloride has not been established. Currently, the only standard for chloride is US EPA's Chronic Freshwater Quality Criteria for Class 2 waters of 230 mg/l and the Secondary Maximum Contaminant Level of 250 mg/l. At these levels aquatic life is compromised. Current chloride conditions in Ditch 66 are significantly lower than the EPA standard and much lower than streams outside of Anoka County with elevated chloride. But given that chloride conditions are higher than the watershed average and have remained at a consistent concentration over the past few years, water quality should be periodically monitored and any changes to the hydrology of the subwatershed should be carefully considered to ensure chronic conditions do not develop in the future.

Chloride is a good indicator of anthropogenic impacts on water resources because it is conservative (not consumed in chemical or biological reactions), highly soluble, and is relatively unavailable from minerals in the quartz rich Anoka Sand Plain Aquifer. Chloride is commonly found in man made substances released into the surface and groundwater via point and nonpoint source pollution.

The ACD did not find any point sources of chlorides to Ditch 66. GIS analysis and field investigations did not locate any industrial, commercial, or residential point sources, although foot surveys of the entire ditch length were not possible due to extensive wetlands and heavy vegetation along the ditch. Water quality data also do not suggest point sources. Chloride levels of Ditch 66 remained consistent throughout the monitoring season and were not runoff driven, as would be expected with most point sources.

Since no direct source(s) of pollution was identified, the ACD considered all possible non-point sources contributing to the high chloride concentrations and conductivity of Ditch 66. The ACD believes the non-point source of pollution is reaching the ditch via groundwater rather than from runoff because there is no difference between chloride levels at baseflow or during storm events. There are three possible non-point sources of chloride to consider in this subwatershed: agriculture, septic systems and road salt.

Fertilizers used in agriculture are likely sources of chlorides in surficial groundwater but, under normal conditions, the concentration of chloride is very small. Research on groundwater contamination identifies nitrates as being the most prevalent contaminant originating from agriculture. Chloride is only mentioned as a minor contaminant, though no studies document the concentration of chloride from these sources. Additionally, in the Ditch 66 subwatershed, only 5% of the land is still being farmed and of that, less than half is adjacent to the stream.

In regard to septic systems, it is likely that there are septic systems contributing chloride to the surficial groundwater. Household products contain chloride, which passes into the surficial groundwater. This contribution of chlorides to the groundwater is thought to be minimal, but assessing the exact magnitude would require onsite inspections and groundwater monitoring.

In addition to the above landuse features, excavated ponds situated in close proximity to the ditch were also examined. Two ponds located within 50 feet of the ditch were found upstream of the Nowthen Blvd crossing. Due to the direct hydrological connection between the ditch (pond level corresponds to the water level in the ditch), the ACD considered the possibility of chemical additives used in the pond affecting chloride levels of the ditch. The ACD researched the typical algae control products used in ponds and did not find any products to contain chlorides or chloride constituents that could be released to the ditch via groundwater.

Taking into account the age of neighborhoods, stormwater management methods, soil characteristics, and prevalence of wetlands, the most likely source of chlorides in the subwatershed is from the use of road salt on county highways and residential streets. Road salt contains higher concentrations of chloride compared to agricultural sources and septic systems and stormwater management and wetlands in the area probably facilitate the infiltration of chlorides to the groundwater.

The US Geological Survey (USGS) examined chloride concentrations in groundwater in the

Twin Cities Metropolitan Area from 1996 - 1998 and detected greater chloride levels in areas with older urban development and in areas with a greater density of impervious surfaces (Fallon and Chaplin, 2001). Supporting research has also documented significantly higher levels in groundwater down gradient of major highways (Andrews, et al 1999). The USGS has concluded that urban areas overlying permeable sand and gravel are more vulnerable to infiltration of chloride-rich runoff from road salt and therefore recharge streams during low stream flow conditions with chloride rich waters (Fallon and Chaplin, 2001). Shingle Creek in Hennepin County was included in the USGS investigation. The USGS documented higher levels of chloride in Shingle Creek, which they have attributed to density of impervious surfaces being treated with road deicers.

Conditions found in the Ditch 66 subwatershed are consistent with the finding of the USGS. The majority of residential developments in this subwatershed have been in existence for the past 30 years. As housing developments became established in the area, the use of road salt on these primary roads as well as on residential streets increased. Over time, chloride from road salt had infiltrated and remained in the surficial groundwater, which then manifests itself as baseflow in Ditch 66.

Major roads crossing the ditch and the surrounding wetlands may be areas where chlorides enter the hydrological system at the highest concentration. These roads include Ramsey Blvd, Nowthen Blvd and St. Francis Blvd. In the spring, chloride rich water directly infuses the surrounding wetlands. The wetland acts as a buffer in that the wetland plants take up a certain portion of the chloride and the water being retained in the wetland dilutes the chloride concentration. Chloride enters the ditch at a lower and more consistent concentration. This interaction would support the higher concentrations detected in the ditch downstream of Nowthen Blvd.

In contrast, a lower concentration of chloride was detected upstream of Nowthen Blvd. at Xenon Street. West of Xenon Street the ditch meanders through a large open wetland setback from residential development and road crossings. Due to the size of the wetland and its distance from development and roads, there is less chloride entering the system. As the ditch flows eastward of Nowthen Blvd, development density increases along with seven additional roads crossing wetlands where road salt is being used. Additional surface and groundwater sampling will be needed to determine relative trends in chloride levels throughout the ditch corridor.

Residential streets are also contributing chlorides to the surficial groundwater. The primary stormwater control method is roadside infiltration swales. Stormwater containing road salt is directed to the roadside for infiltration to the surficial groundwater and eventually recharges the ditch. If stormwater was conveyed directly to the ditch via a curb and gutter stormwater system, it is expected that chloride conditions would be erratic with the highest concentration in the spring.

Groundwater data from the USGS in the Ditch 66 watershed also supports the theory that chlorides infiltrate into surficial groundwater and then slowly enter the ditch. Groundwater samples taken from a depth of 14 and 29 feet. Mean chloride concentrations were 32 mg/l at both depths (n=5 at both depths). The maximum chloride concentration for the 14 ft depth was 77 mg/l in 1987 and 47 mg/l at the 29 ft depth in 1985.

These results beg the question, “why don’t all ditches and streams have elevated chlorides originating from groundwater?” The answer is probably multifaceted. To some extent, all Anoka streams in urban areas are affected by chlorides from road salt. Ditch 66 is unique in that it is fed primarily by groundwater; it is relatively short (4.25 miles) and flows under eight road crossings, three of which are main roads. Other streams in the watershed are much longer and have the advantage of dilution from tributary flow that dilutes chlorides being transported by surficial groundwater to an acceptable level. Some other streams have flashy concentrations which coincide with storm flow because stormwater conveyances do not allow chlorides to enter surficial groundwater or wetlands where they are released more slowly.

MANAGEMENT IMPLICATIONS

The management implications of these findings lie in two areas: road salt usage and hydrology. Simply reducing the amount of road salt being applied to the roads is an option with limited applicability. Alternative chemicals and/or a sand/salt hybrid could be considered, but public safety should remain the priority.

The more important aspect to focus on is the hydrological balance of this subwatershed. In order to devise effective methods of managing water quality and quantity, it is important to gather more data about the complex interaction between the ditch and surficial groundwater and wetlands. Current data suggests that updating of the ditch or other stormwater conveyances will affect the temporal release of chlorides. If stormwater is carried by curb and gutter systems directly to the ditch without infiltration to groundwater, chlorides will fluctuate widely with stormwater runoff. Ditch maintenance could have the same effect if stormwater is released more quickly from adjacent wetlands. Any changes to the hydrology of the subwatershed should be carefully considered to ensure that water quality conditions are not exasperated.

Regardless of changes in hydrology, monitoring of chlorides should continue. Current levels are well below levels that will affect aquatic life or human health. If future monitoring detects rising chloride concentrations, corrective actions should be taken at that time. It is most likely that any increases will be due to a new chloride source for which an effective remediation may be available, or to increased road salting over several years.

Literature Cited

Fallon, J., and B. Chaplin. 2001. Chloride-related studies in streams and ground water of the Twin Cities Metropolitan Area, Minnesota, 1996 – 1998 – A summary of published and new results – Extended Abstract. U.S. Geological Survey (study to be published in 2002).

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