DRAFT RU220

MEMORANDUM CH2M HILL

Nonpoint Source Evaluation

TO: CCBWQA Technical Review Committee

FROM: Jim Wulliman/CH2M HILL

DATE: May 16, 1997

This draft memorandum documents a nonpoint source evaluation conducted for the Cherry Creek Basin Water Quality Authority (CCBWQA). The evaluation consisted of the following four work elements:

- Identify Pollutant Reducing Facilities
- Quantify Phosphorus Removal Capability
- Review Construction Site Erosion Control
- Recommend Future Phosphorus Reducing Activities

The overall objectives of the project were to identify what measures have been taken to date to control nonpoint sources in the watershed and to evaluate the overall effectiveness of the measures. A follow-up objective was to provide recommendations for future nonpoint source control activities.

Identify Pollutant Reducing Facilities

Work element: Identify constructed Pollutant Reducing Facilities (PRFs) presently in the Basin.

For the purposes of this work, a constructed PRF was defined as a facility, such as the following, that was constructed with the expressed goal of reducing phosphorus or other pollutants:

- A facility that provides for extended detention of captured runoff (drain time of 12 hours or more of upstream water quality capture volume [WQCV], with WQCV defined per Volume 3 of the Urban Drainage and Flood Control District's Criteria Manual).
- A facility that provides a permanent pool with a surface area greater than 0.1 acre.
- A facility that provides a constructed wetland with a surface area greater than 0.1 acre.

Pollutant reducing facilities were categorized in two tiers. Tier 1 facilities consist of PRFs constructed adjacent to Cherry Creek Reservoir where monitoring data have been collected, plus other facilities identified herein as determined by the Authority's Technical Review Committee (TRC). Tier 1 facilities were funded in part or in whole by the Authority. Tier 2 facilities consist of constructed PRFs located upstream in the basin, where monitoring data have not been collected. Tier 2 facilities have been constructed generally by developers or entities other than the Authority.

Four Tier 1 PRFs were identified, as follows:

- Shop Creek Water Quality Improvements
- Quincy Outfall Water Quality Improvements
- Cottonwood Creek (Perimeter Road) Water Quality Improvements
- East Shade Shelter Water Quality Improvements

Tier 2 facilities were identified based on interviews with staff from each land use jurisdiction in the watershed. Staff from Arapahoe County, Douglas County, the Town of Parker, and the Cities of Aurora, Castle Rock, and Greenwood Village each identified the Tier 2 facilities that they were aware of. A total of thirty-five Tier 2 PRFs were identified. The identified PRFs were located in the Cherry Creek, Cottonwood Creek, and direct flow drainage areas. The Tier 2 PRFs exist within five of the six land use jurisdictions.

Other PRFs may exist in the watershed that the interviewed staff were not aware of. If additional PRFs are identified in the future, or if other PRFs are constructed, it is recommended that they be added to this inventory. Facilities in the watershed such as ponds and natural wetland areas, even though not constructed as pollutant reducing facilities, may actually provide water quality benefits; these could also be added to the inventory in the future.

Figure 1 provides a map showing the location of each of the Tier 1 and Tier 2 PRFs and their upstream drainage areas. Table 1 provides summary information for all of the PRFs.

Each of the Tier 1 and Tier 2 PRFs were examined in the field and photographed. Information pertaining to the water quality features of each PRF was obtained and compiled. Appendix A provides photographs of each of the PRFs inventoried. Appendix B provides an initial database of design information for each PRF. The format of the database follows the recommendations of an EPA-sponsored advisory panel seeking to establish standard protocols for collecting data for water quality facilities. The database forms in Appendix B have been filled out with any design information available during this study.

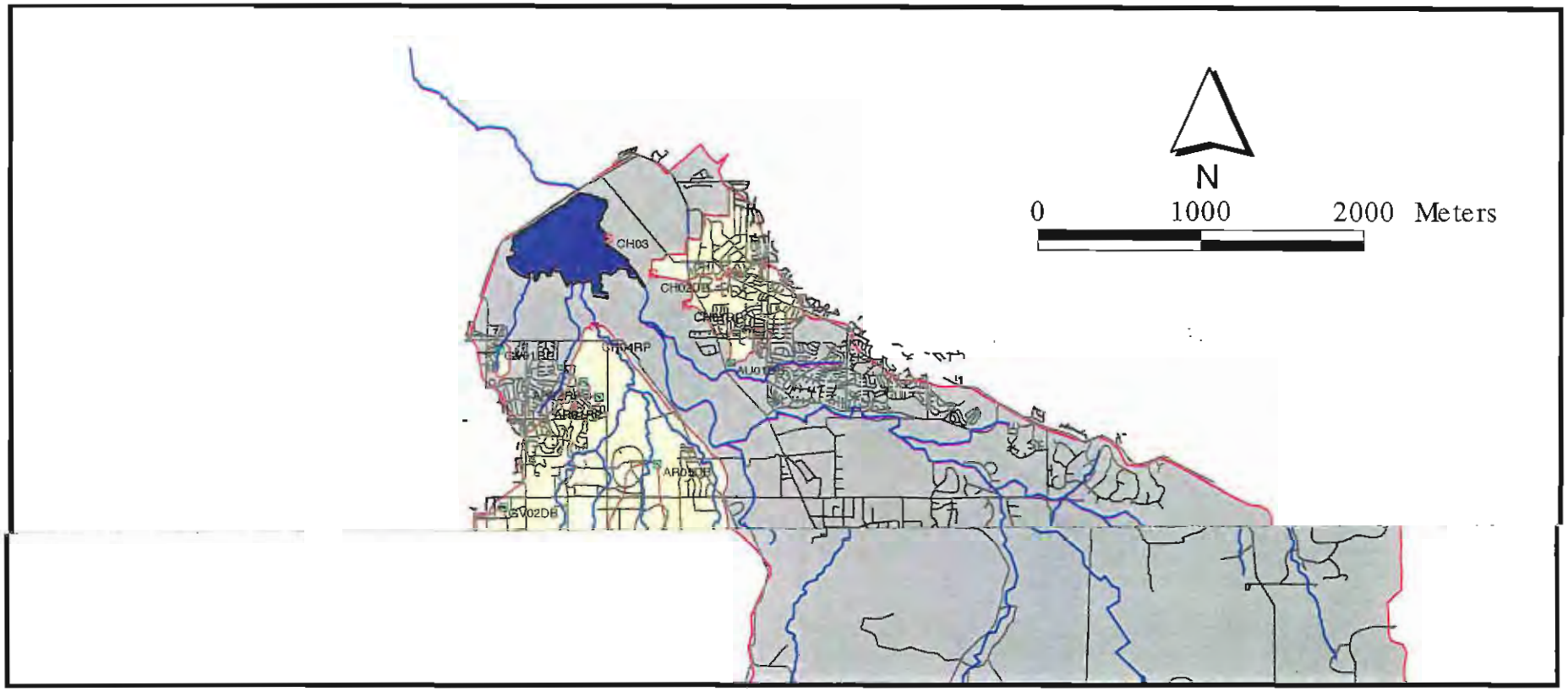
Quantify Phosphorus Removal Capability

Work Element: Prepare estimates of long-term average phosphorus removals for each PRF using actual data or empirical evaluation.

For the Tier 1 and Tier 2 PRFs, estimates were prepared of total suspended solids (TSS) and total phosphorus (TP) removals for each PRF. These estimates are intended to represent average annual removals over a number of years, recognizing that removals in any given year will vary and could be higher or lower than the average estimates, depending on hydrologic factors and watershed conditions. The estimates were prepared based on available data, and were supplemented with an empirical evaluation where data were limited. These estimates are intended to provide an initial quantification of removals associated with the PRFs, are generally on the conservative (low) side, and are to be reassessed over time as more data are obtained.

Evaluation of Existing Monitoring Data

Flow, TSS and TP load data collected for Shop Creek, the Quincy Outfall, and Cottonwood Creek were evaluated. The raw data were examined and analyzed as the basis of preparing removal estimates for the PRFs, as opposed to using summaries of data or performance



Tier 1 PRF
Tier 2 PRF
Streams
Reservoirs
Transportation
PRF Basin
Cherry Creek Basin

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FIGURE 1

Pollutant Reducing Facilities (PRF's) in Cherry Creek Watershed

January 1997

TABLE 1

Tier 1 and Tier 2 PRF Information

ID Number	Description	Jurisdiction	Water Quality Capture Volume Ac-ft	Drainage Area Acres
TIER 1 PRFs				
CH01RP	Shop Creek Water Quality Improvements	Cherry Creek State Park	9.1	520
CH02DB	Quincy Outfall Water Quality Improvements	Cherry Creek State Park	8.8	530
CH03	East Shade Shelter Shoreline Stabilization Project	Cherry Creek State Park	N/A	N/A
CH04RP	Cottonwood Creek Water Quality Improvements	Cherry Creek State Park	22	7500
TIER 2 PRFs				
AR01RP	Cherry Creek Vista III Filing 16-A East Wetland Basin	Arapahoe County	1.4	28
AR02RP	Cherry Creek Vista III Filing 16-A West Wetland Basin	Arapahoe County	6.8	21
AR03RP	Rampart Business Center Filing No. 6 Basin	Arapahoe County	1.2	140
AR04RP	Inverness Filing 17 located in Inverness Business Park	Arapahoe County	1.7	33
AR05DB	Lonetree Basin L3, Arapahoe County	Arapahoe County	17	980
AU01DB	Shalom Park Subdivision Detention Basin, Aurora	City of Aurora	2.2	110
DO01DB	Cottonwood Subdivision Filing No. 11 Detention Basin	Douglas County	1.8	260
DO02DB	The Pinery/High Prairie Farms Filing No. 3, Detention Basin A	Douglas County	0.5	43
DO03DB	The Pinery/High Prairie Farms Filing 3, Detention Basin B	Douglas County	0.5	45
DO04DB	The Pinery Filing No. 22, Detention Basin A1	Douglas County	0.1	19
DO05DB	The Pinery Filing No. 22, Detention Basin A2	Douglas County	0.3	39
DO06DB	The Pinery Filing No. 22, Detention Basin B1	Douglas County	0.1	16
DO07DB	The Pinery Filing No. 22, Detention Basin B2	Douglas County	-	16
DO08DB	The Pinery Filing No. 22, Detention Basin No. C1	Douglas County	0.3	37
GV01RP	Dayton Farms Detention Basin	Greenwood Village	1.7	77
GV02DB	Greenwood Village Municipal Maintenance Base	Greenwood Village	0.1	7.2
PA01DB	Parker United Methodist Church (North)	Town of Parker	0.1	3.8
PA02DB	Parker United Methodist Church (2nd Basin from North)	Town of Parker	0.4	3.8
PA03DB	Parker United Methodist Church (3rd Basin from North)	Town of Parker	0.4	3.8
PA04DB	Parker Vista Subdivision (Stonehedge and Main Street)	Town of Parker	0.8	42
PA05DB	Parker Vista(North Detention Basin)	Town of Parker	0.4	16
PA06DB	Canterbury Crossing Detention Facility	Town of Parker	10	16
PA07DB	Willow Ridge Filing 1	Town of Parker	0.5	22
PA08DB	Willow Ridge Filing 2	Town of Parker	1.3	34
PA09DB	Willow Park West	Town of Parker	2.6	18
PA10DB	Willow Park East	Town of Parker	9.4	21
PA11DB	Parker Marketplace Phase 2 Detention Facility	Town of Parker	0.2	5.3
PA12DB	Bradbury Ranch	Town of Parker	1.9	380
PA13DB	Baldwin Pond	Town of Parker	0.4	280
PA14DB	Joint Use Facility Detention Basin 1	Town of Parker	0.1	2.4
PA15DB	Joint Use Facility Detention Basin 2	Town of Parker	0.4	4.8
PA16DB	Clarke Farms Detention Basin	Town of Parker	11	290

results provided in the Authority's annual reports or monitoring summaries. Data collected included continuous flow measurements and periodic water quality samples for base flow conditions and discrete storm events. Inflow and outflow measurements and water quality samples were evaluated for the Shop Creek and Quincy Outfall PRFs. Only inflow measurements and samples were examined for the Cottonwood Creek PRF, since it was just constructed in December of 1996. The monitoring period evaluated consisted of the following:

- Shop Creek - 1990, 1991, 1992, 1995, 1996
- Quincy Outfall - 1996
- Cottonwood Creek - 1994, 1995, 1996

Data for 1990, 1991, and 1992 were collected by Advanced Sciences, Inc. (ASI), while data for 1994, 1995, and 1996 were collected by Chadwick Ecological Consultants (CEC). Data was not collected in 1993. Much of the monitoring information and results for Shop Creek for the years 1990 through 1992 came directly from a document entitled *Internal UDFCD Report on the Joint Shop Creek Pond-Wetland System Performance* completed in December, 1996. Shop Creek data for 1994 were not evaluated by UDFCD because of limited data points and questionable data, and were not used herein for the same reasons.

The following approach was used to estimate TSS and TP loads and removal efficiencies for Shop Creek, Quincy Outfall, and Cottonwood Creek (a complete set of calculations is included in Appendix C):

1. Determine Annual Storm Flow and Base Flow Volumes - Measured runoff volumes were subdivided into base flow volumes and storm flow volumes for each of the three drainages. The separation of data into base flow or storm flow events was based on the magnitude of flow as indicated by the data, and by documentation provided with the raw data.

   Flow data were only collected during the spring/summer months (April/May to September/November) and not during the winter months. In order to determine annual volumes, the storm and base flow volumes for the unmeasured winter months had to be estimated. The storm volumes for the unmeasured winter months, for the purposes of this study, were estimated by a ratio of the total measured annual storm flow volume and the cumulative percentage of average annual precipitation (Denver) for the measured period. An example of this is as follow:

   -measured annual storm flow volume = 165 acre-feet (af)
   -percentage of average annual precipitation for the measured period = 70%
   -total annual storm flow volume = 165/0.7 = 236 af

   The base flow volumes for the winter months were estimated to be 67% of the average monthly measured base flow volumes. The 67% ratio is an assumed value selected to approximate the reduction in base flow that usually occurs in winter months due to decreases in precipitation and irrigation.

   To get a better idea of base flow and storm flow contributions during the winter months, it may be desirable to provide for some level of flow monitoring during these

months, perhaps just for one or two seasons, to establish relative contributions during this period.

2. Determine Average TP and TSS Concentrations - The water quality sample data consisted of concentrations of TP and TSS in milligrams/liter (mg/l). Typically 15 to 20 water quality samples were collected annually during base flow conditions on each of the three drainages. Approximately 10 water quality samples were collected during storm events annually on each drainage. Average TP and TSS concentrations were determined separately for base flows and storm flows, since storm flow concentrations were generally larger than base flow concentrations.

3. Determine Average Annual TP and TSS Loads - Average annual TP and TSS inflow and outflow loads were determined for the drainages by multiplying the average concentrations by the average annual flow volumes. This was done separately for base flows and storm flows.

4. Determine PRF Removal Efficiencies - PRF removal efficiencies were also accounted for separately for base flows and storm flows. TSS and TP loads removed were determined by subtracting the outflow loads from the inflow loads. PRF removal efficiencies were then determined by dividing the removed loads by the total inflow loads. Shop Creek removal efficiencies were taken from the UDFCD report. Since Cottonwood Creek outflow data was not available and only one year of results was available for the Quincy Outfall, the removal efficiencies for these PRFs were estimated using an empirical evaluation, described in the following section. The empirical evaluation was calibrated to yield comparable results for the Shop Creek and Quincy Outfall PRFs as the actual monitoring data.

Empirical Evaluation Where Data Were Limited

Where phosphorus removal data were limited, an empirical evaluation was undertaken to estimate the average annual TSS and TP removal. The empirical evaluation was based on a number of underlying assumptions that are discussed below. The evaluation is not intended to be a prediction of actual day-to-day performance of the PRFs, which will vary according to hydrologic and inflow loading factors, but was undertaken to provide an order-of-magnitude estimate of the expected average performance of the PRFs over the long term.

The following approach was used to undertake the empirical evaluation:

1. Each PRF was modeled using UDFCD's CUHP and UDSWM2 programs to estimate inflow hydrographs, pond routing and peak outflows. The 2-year event was selected to represent long-term average annual hydrologic conditions, consisting of a range of storms both smaller and larger than the 2-year event. The 2-year event is larger than the majority of the monitored events, so its use provides results that are generally conservative. On the other hand, using the 2-year event provides for representation of large storms that may only occur once every few years, and can generate substantial TSS and TP loading. Inflow hydrographs were derived from existing UDFCD models for Shop Creek, Quincy Outfall, and Cottonwood Creek.

2. Estimates of sediment (TSS) loading from watershed areas upstream of the PRFs were developed based on an average annual sediment yield of 0.1 tons per acre of upstream

watershed. This sediment yield is an assumed value that is of the same order-of-magnitude as information published by the US Geological Survey (USGS, 1987) and total suspended solids (TSS) data obtained for Shop Creek and Cottonwood Creek. Higher estimates of sediment yield for the Cherry Creek watershed have been identified (BRW, 1985), but most of this yield was attributed to the 1965 flood. As the Authority pursues quantifying actual TSS loading in areas upstream in the watershed, it is recommended that the PRF removal estimates summarized herein be updated based on the actual TSS loadings.

3. Observation of sediments deposited in Cherry Creek Reservoir confirms that the particle size range of eroded sediments appears to be relatively fine (generally consisting of silts and clays). A representative distribution of particle sizes of the sediment yield analysis was estimated based on generalized data published by EPA as part of the Nationwide Urban Runoff Program (NURP) (EPA, 1986). The "typical" particle size distribution defined in the NURP study was modified by eliminating the course size ranges and redistributing the silt and clay size ranges to total 100 percent to the sample. The resulting distribution, shown in Table 2, was assumed to be generally representative of the water-borne sediments eroding from the project area.

TABLE 2
Assumed Sediment Characteristics

Sediment Size Class	Description	Size Range (mm)	Geometric Mean (mm)	Fall Velocity (fps)	Size Distribution (%)
1	Coarse Silt	0.0625-0.0313	0.0442	0.0053	37
2	Medium Silt	0.0313-0.0156	0.0221	0.00122	35
3	Fine Silt	0.0156-0.00781	0.0111	0.00032	15
4	Very Fine Silt	0.00781-0.00391	0.00552	0.000083	8
5	Clay	0.00391-0.00195	0.00276	0.0000295	5

4. The TSS removal efficiency of each of the PRFs was modeled. The model used to estimate sediment removal was recommended by the EPA as a suitable method of analysis for dynamic sedimentation (EPA, 1986). Sediment removal is expressed by the following equation:

$$R = 1 - \left[1 + \frac{1}{n} \bullet \frac{v_s}{Q/A} \right]^{-n}$$

where :

R	=	fraction of initial solids removed (R * 100 = % Removal)
v_s	=	settling velocity of particles
Q/A	=	rate of applied flow divided by surface area of basin (an "overflow velocity," often designed the overflow rate)
n	=	a parameter which provides a measure of the degree of turbulence or short-circuiting, which tends to reduce removal efficiency n = 1 (very poor); n = 3 (good); n > 5 (very good)

The equation was applied to discrete time increments of the detention pond outflow hydrographs and weighted average removal efficiencies were calculated based on the runoff volume passing during each time increment.

5. The resulting removal efficiencies were tracked separately for each of the five sediment size classes. Net sediment removal efficiency was then calculated for each PRF.

6. Monitoring data for the Shop Creek water quality project showed that its removal efficiency for TP during storm events was on average 70-percent of its removal efficiency for storm flow TSS. Storm flow TP removal efficiency was calculated for each PRF by multiplying TSS removal efficiency by 70-percent. Estimates of expected base flow removal efficiencies were made for the Quincy Outfall and Cottonwood Creek facilities based on the four years of monitoring data for Shop Creek and the one year for Quincy.

For the East Shade Shelter Water Quality Improvements, three soil samples were obtained to ascertain a relationship between shoreline sediments and TP. This relationship showed that every cubic yard of soil along this section of shoreline contained approximately two pounds of TP. Estimates of shoreline sediment inflow to the lake were prepared for conditions before and after the project and TP removed was calculated based on the difference between the estimated TP loading before and after the project.

Results

Based on the approach described above, estimates of TSS and TP removal efficiencies for the four Tier 1 and ten of the Tier 2 PRFs are indicated in Table 3. In general, the removal efficiencies shown in Table 3 are on the average to high side, compared to the range of efficiencies observed regionally and nationally for similar facilities.

The average annual number of tons of TSS and pounds of TP estimated to be removed by each PRF are also shown in Table 3. In any given year, actual removals may vary from the average estimates by 50-percent or more. The 25 Tier 2 PRFs that are not shown in Table 3 each were estimated to remove one to two pounds or less TP on an annual basis, due to their small size, small drainage basins, or, in some cases, lack of maintenance.

A number of figures were prepared to compare some of the inflow and removal data for the Shop Creek, Quincy Outfall, and Cottonwood PRFs. Figures 2 and 3 indicate that TSS and TP inflow concentrations are on average larger for storm flows than for base flows.

Figures 4, 5, and 6 show that base flows make up half or more of the annual runoff volume, but storm flows account for the majority of the TSS and TP loading. These three figures also indicate that, on a per acre basis, runoff, TSS and TP loading are higher in the Shop Creek watershed than in the Quincy Outfall and Cottonwood Creek watersheds.

Figures 7 and 8 compare the monitored removal efficiencies for the Shop Creek PRF and estimated removal efficiencies for the Quincy Outfall and Cottonwood Creek PRFs. Figures 9 and 10 indicate estimated TSS and TP loads into and out of the three PRFs.

TABLE 3

Summary of Removal Efficiency for Tier 1 and Tier 2 PRFs

PRF	Estimated TSS Removal Efficiency	TSS In (tons/yr)	TSS Removed (tons/yr)	TSS Out (tons/yr)	Estimated TP Removal Efficiency	TP In (lb/yr)	TP Removed (lb/yr)	TP Out (lb/yr)
Tier 1								
Shop Creek	82%	51	42	9	54%	336	180	156
Quincy Outfall	84%	21	18	3	66%	158	104	54
Cottonwood Creek	61%	481	293	188	40%	1098	438	661
East Shade	80%	15	12	3	80%	23	18	5
Total: Tier 1 PRFs		568	365	203		1615	740	876
Tier 2								
Cottonwood Subdivision Filing 11	84%	26	22	4	59%	26	15	11
Clarke Farms Detention Facility	90%	29	26	3	63%	29	19	11
Baldwin Detention Facility	42%	28	12	16	29%	28	8	20
Bradbury Ranch Facility	80%	38	30	8	56%	38	21	17
Dayton Farms	85%	8	7	1	60%	8	5	3
Shalom Park	90%	10	9	1	63%	10	6	4
Lonetree Pond L3	72%	98	70	27	50%	98	49	48
Meridian Pond 2	85%	42	36	6	60%	42	25	17
Meridian Pond 3	90%	8	7	1	63%	8	5	3
Rampart Filing 6	54%	14	8	7	38%	14	5	9
Total: Tier 2 PRFs		301	227	74		301	159	142
Total: Tier 1 and Tier 2 PRFs		869	592	277		1916	899	1018

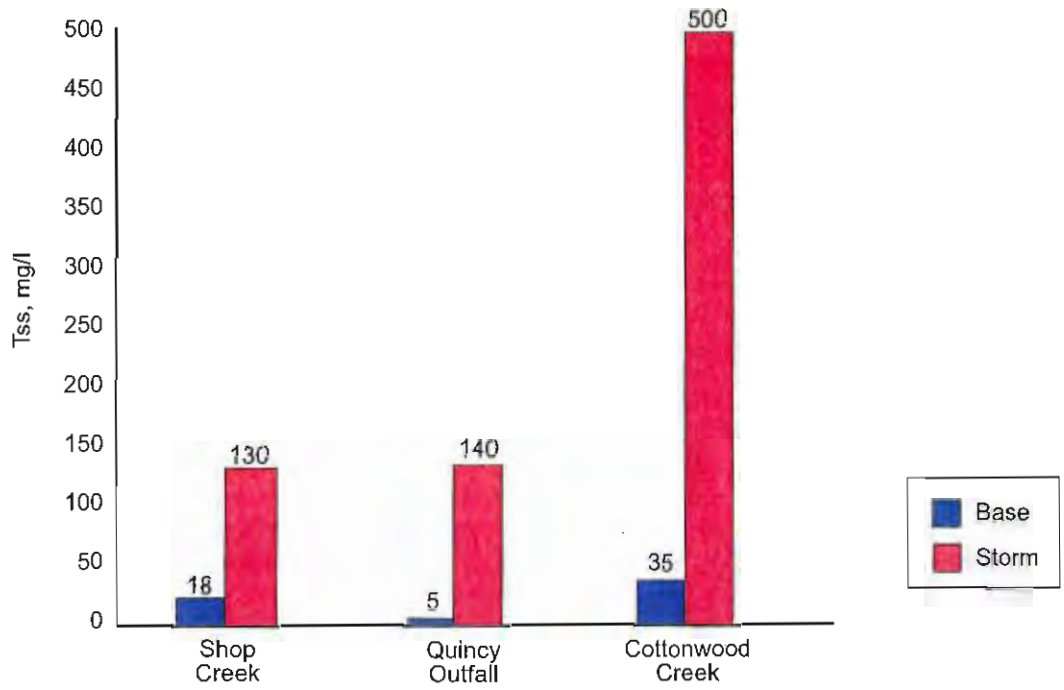


Figure 2
Average Base Flow and Storm Flow TSS Concentration

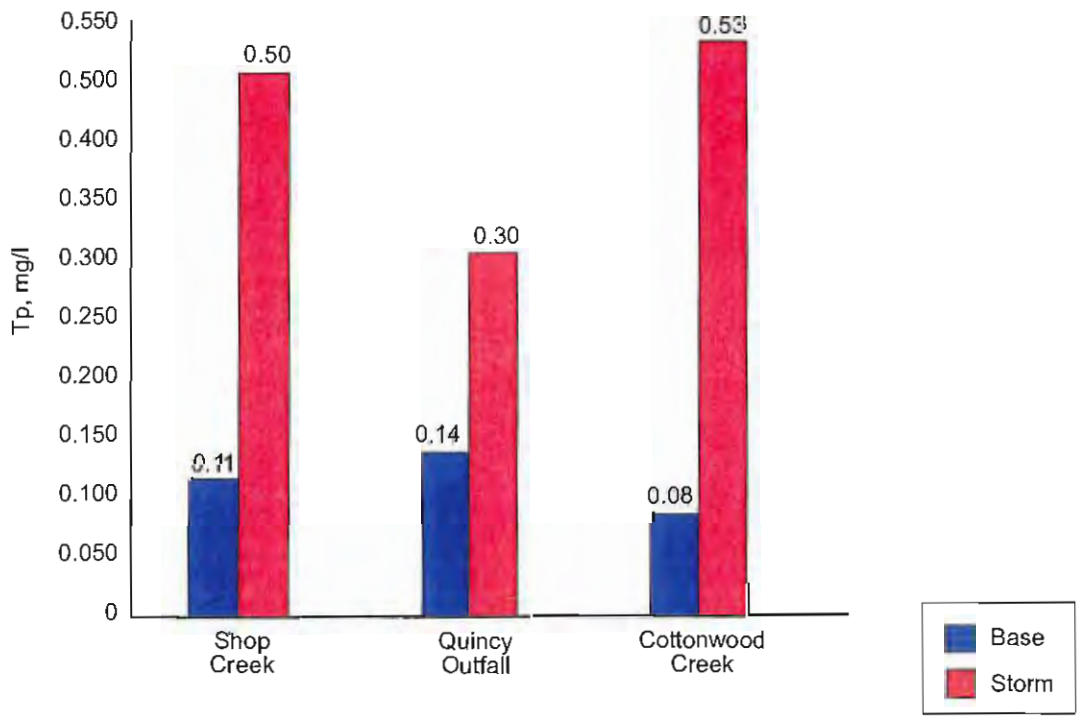


Figure 3
Average Base Flow and Storm Flow TP Concentration

Based on data from 1990, 1991, 1992, 1995, and 1996 for Shop Creek, 1996 for Quincy Outfall, and 1994, 1995, and 1996 for Cottonwood Creek.

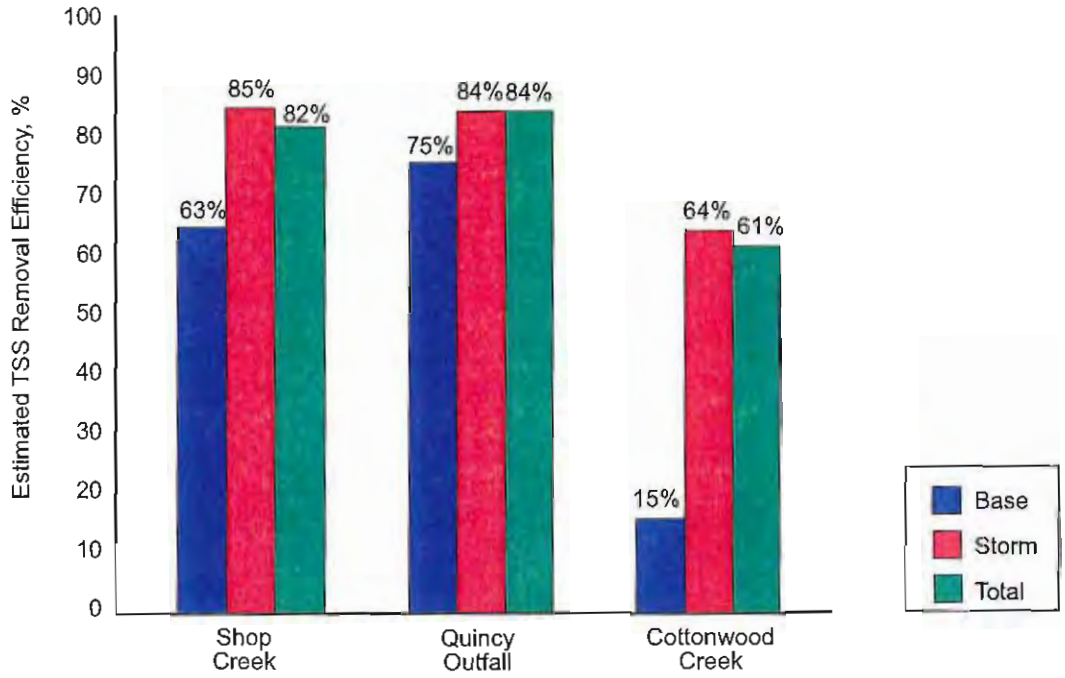


Figure 7
Estimated TSS Removal Efficiency

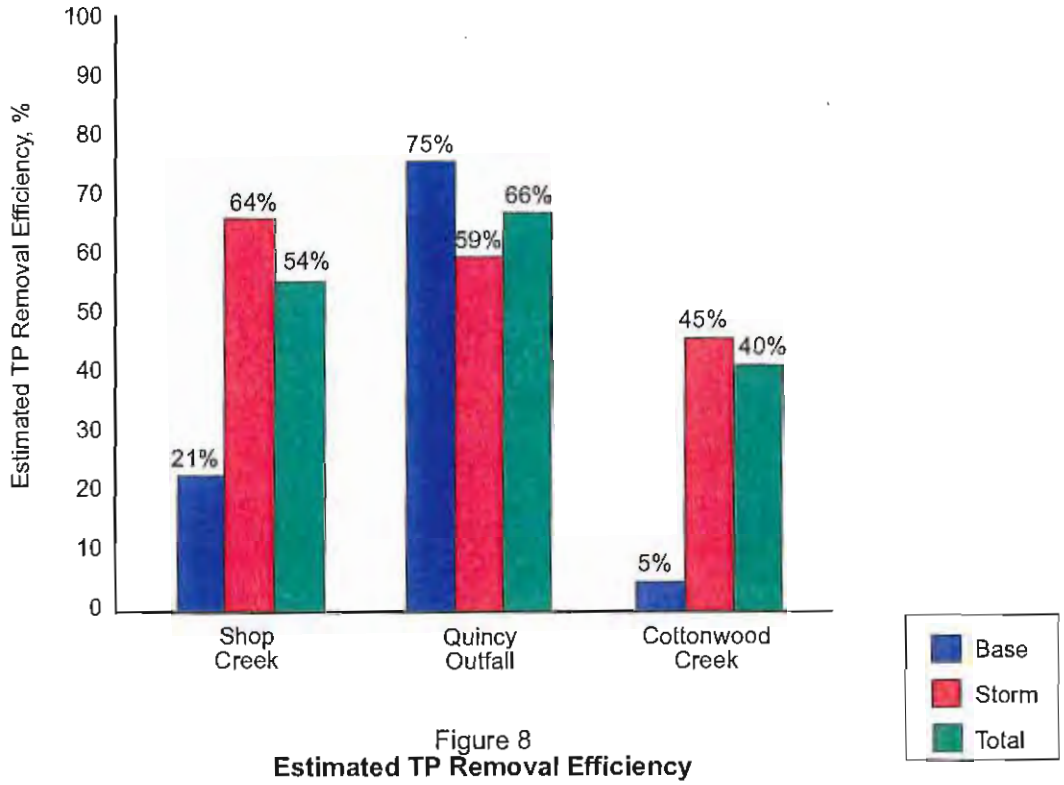


Figure 8
Estimated TP Removal Efficiency

Based on data from 1990, 1991, 1992, 1995, and 1996 for Shop Creek. Based on emplrical estimate for Quincy Outfall and Cottonwood Creek.

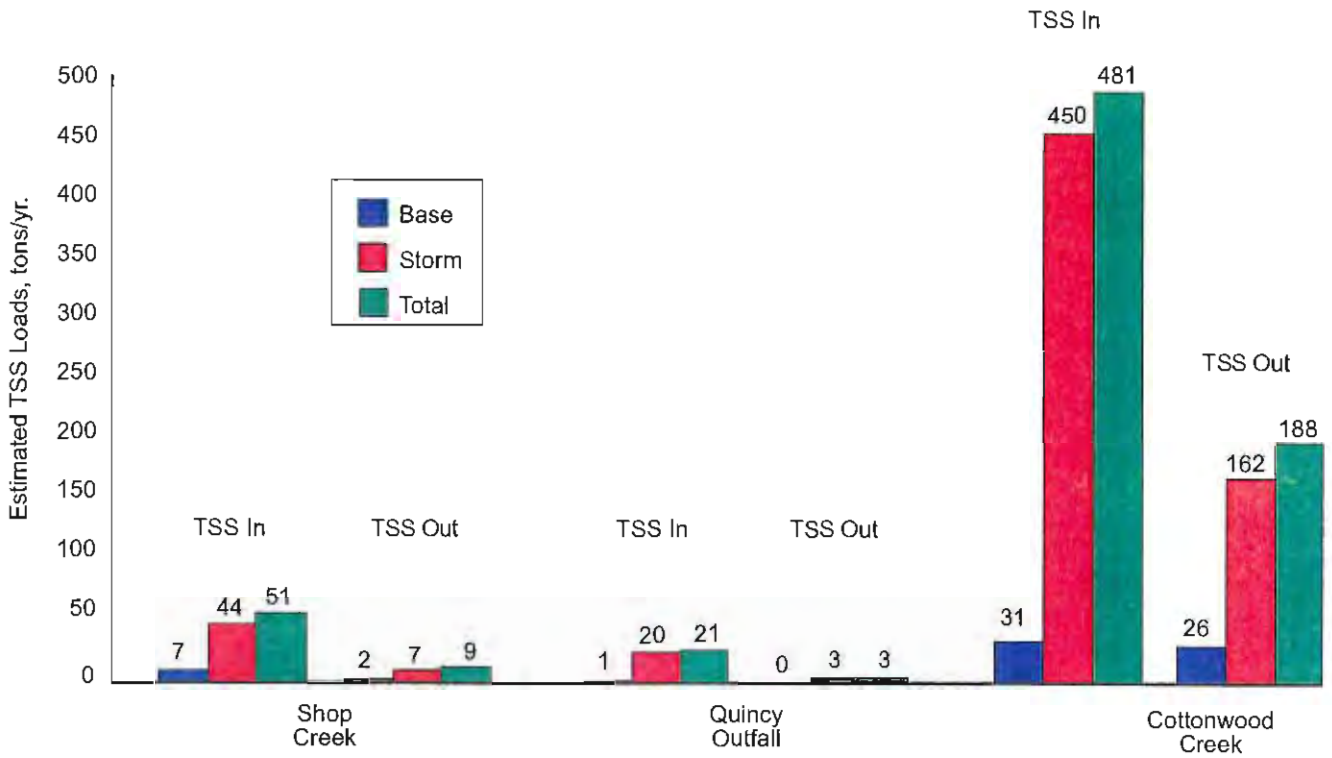


Figure 9
Estimated TSS Inflow and Outflow Loads

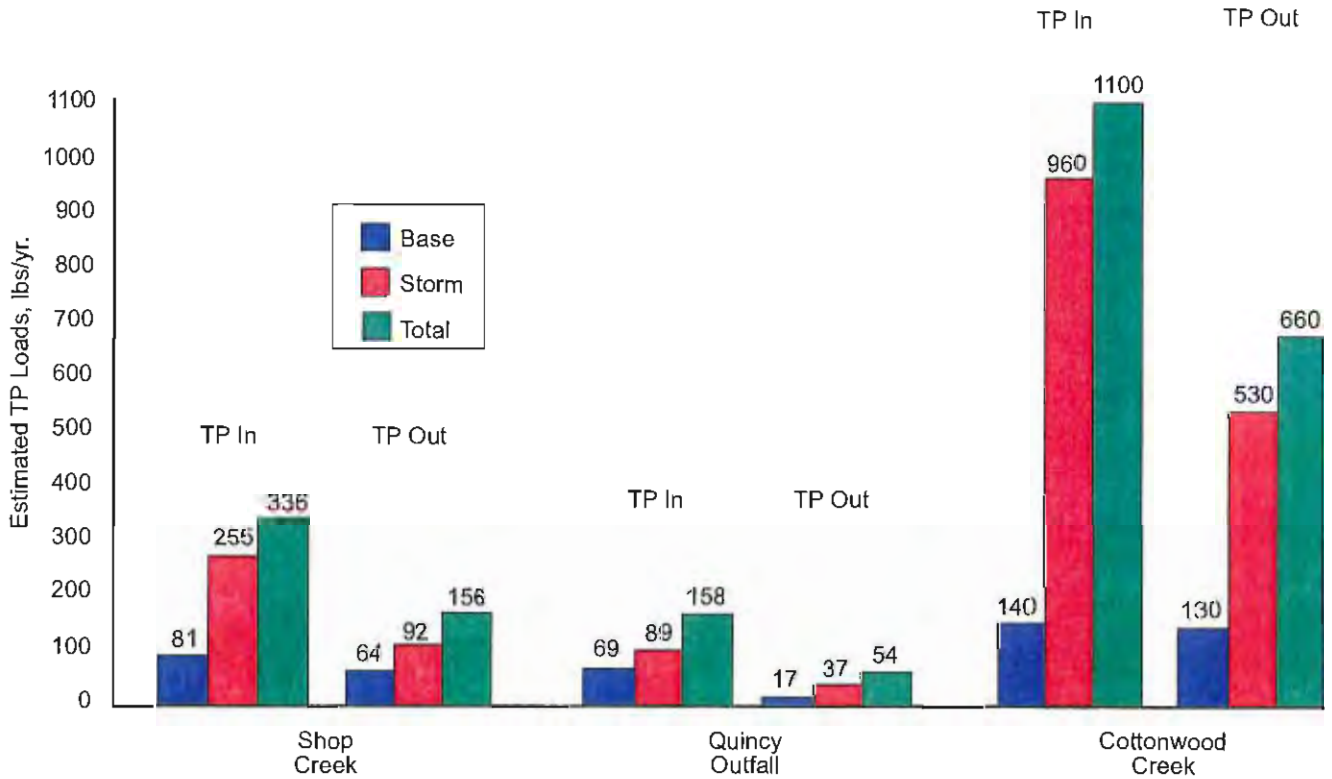


Figure 10
Estimated TP Inflow and Outflow Loads

Based on data from 1990, 1991, 1992, 1995, and 1996 for Shop Creek. Based on empirical estimate for Quincy Outfall and Cottonwood Creek.

Construction Site Erosion Control Review

Work Element: Review existing construction site BMPs to determine if the design, implementation, and maintenance of mitigation measures are meeting their original intent.

Discussions were held with staff from each of the six land use jurisdictions regarding programs to control erosion during construction. Ten current construction projects in the six jurisdictions were observed in the field to assess the effectiveness of erosion control measures. These sites are shown in Figure 11.

Active programs to review erosion control plans and inspect erosion control measures in the field are in place in five of the six land use jurisdictions. The sixth jurisdiction, the City of Aurora, is planning to set up a program so that it might be in place in January, 1998.

Three of the jurisdictions, the Town of Parker, Douglas County, and Greenwood Village, have similar erosion control criteria, originally developed by HydroDynamics. These criteria are based on estimating sediment yield for pre-construction and during-construction conditions and incorporating erosion control measures to reduce sediment yield during construction to a specific performance standard.

Arapahoe County has erosion control criteria that is similar to the standards identified in Volume 3 of UDFCD's Urban Storm Drainage Criteria Manual. Castle Rock uses both the Douglas County Manual and the UDFCD's Volume 3 Manual.

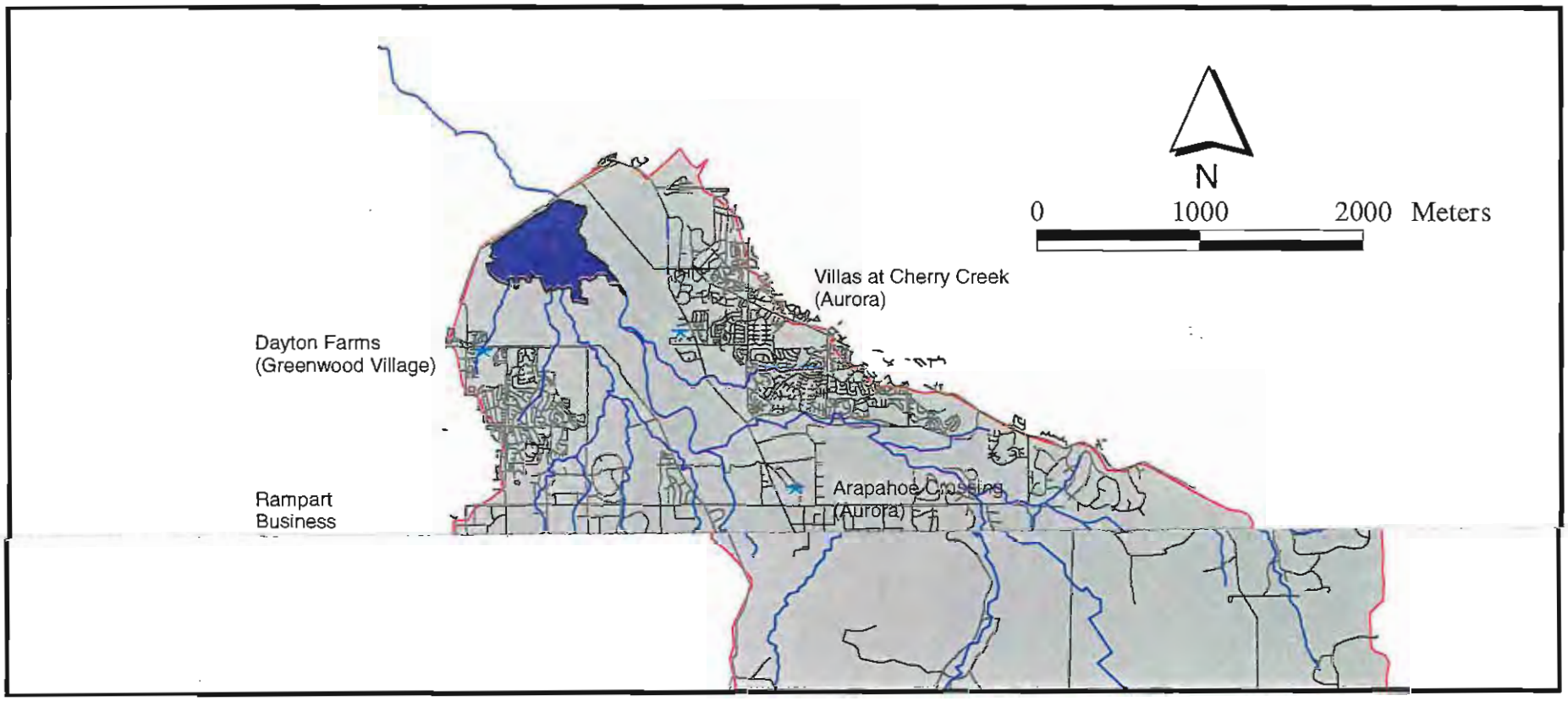
The erosion control criteria used by the land use jurisdictions identify the following types of measures:

- Sediment traps and sediment basins
- Silt fence and straw bale dikes
- Vehicle tracking control
- Inlet protection
- Surface roughening, mulching, and cover crops
- Phasing work to limit area of disturbance
- Filter strips

Based on discussions with erosion control staff, as well as observations of the ten construction sites, the single most effective erosion control measure seems to be the use of sediment traps and sediment basins. These need to be located at the downstream points of a disturbed site, be properly sized and overexcavated to allow for sediment storage, and promptly cleaned out when sediment fills the storage area. Sediment basins need to be installed prior to other land disturbing activities and be configured so that all of the disturbed site drains to one or more traps or basins.

Other erosion control measures seen as effective by erosion control staff include vehicle tracking controls, phasing work to reduce areas of disturbance, and promptly mulching and establishing cover crops after finish grading.

Erosion control measures viewed as less effective in practice include the use of straw bale dikes and silt fence, inlet protection, and filter strips. Straw bale dikes and silt fences are often installed improperly so that they do not provide an effective barrier to sediment. Also, straw bale dikes and silt fences too often are relied upon as a substitute for sediment traps and sediment basins. Drainage areas upstream of these "barriers" are often allowed



Construction Site
Streams
Reservoirs
Transportation
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FIGURE 11

Construction Sites Visited in Cherry Creek Watershed

January 1997

to become too big, so that runoff and sediment can overtop or "blow out" the straw bale dike or silt fence. Silt fence is most likely to be effective if it is properly installed with a firmly backfilled trench and if it is used selectively in small drainage areas.

Inlet protection measures have been problematic, according to staff. Inlet protection, when it functions, often leads to tracking and maintenance problems when sediment accumulates in street areas. One inspector said that he has observed crews remove inlet protection at the end of a job and flush the sediment down the inlet to clean up the street. As mentioned above, a sediment trap or basin located downstream of a storm sewer system is usually an effective control measure, combined with flushing of sediments, at the end of construction, that may have accumulated in inlets and storm sewer pipes.

It is recommended that the Authority continue to coordinate with the land use jurisdictions regarding their construction erosion control programs. In general, a greater overall reliance on the proper installation and maintenance of sediment traps and basins will help to reduce sediment and phosphorus loading from construction sites.

Recommend Future Phosphorus Reducing Activities

Work Element: Recommend future cost effective phosphorus reducing projects or activities in the Basin.

This section provides an initial list of recommendations for future phosphorus reducing activities and projects for the Authority's consideration. The list is preliminary in nature; its purpose is to provide a starting point for subsequent discussions. The list will be revised and prioritized based on input received from members of the TRC and the Authority as a whole.

Working with Land Use Agencies

1. **Regional Water Quality Planning.** We recommend that the Authority undertake water quality master planning to identify optimum locations and configurations of water quality facilities in the watershed. It will be beneficial to evaluate onsite versus various regional alternatives for implementing water quality facilities in the watershed. Of special importance is evaluating effective methods for stabilizing streams in the watershed. We recommend that the water quality planning take place in cooperation with land use agencies and the Urban Drainage and Flood Control District (UDFCD) and that opportunities to incorporate water quality features into quantity facilities, such as 100-year detention ponds, be explored. A recent example of this kind of cooperative quantity/quality planning is the Lower Cottonwood Creek Water Quality Plan (November, 1996). An upcoming planning example is the Cherry Creek Corridor Plan in Arapahoe County (starting February, 1997).

2. **Construction Erosion Control Program.** We recommend that the Authority continue to work with the land use agencies to establish uniform criteria for erosion control during the construction phase. Improvements to existing programs can be made, especially in identifying the most effective BMPs and in the areas of maintenance and enforcement. We recommend that the Authority coordinate with the land use jurisdictions to establish a higher level of consistency and overall effectiveness in their construction erosion control criteria and programs.

3. **Water Quality Criteria for New Development.** We recommend that the Authority work with the land use agencies to consider the establishment of uniform development criteria for stormwater quality enhancement after the construction phase is completed. These criteria may call for the implementation of permanent structural or nonstructural best management practices (BMPs). We recommend that the Authority work with land use agencies to incorporate permanent water quality BMPs into their plan review, inspection and enforcement program for new development.

4. **Maintenance of Water Quality Facilities.** We recommend that the Authority establish a program for maintaining permanent water quality facilities. If water quality facilities are not maintained, they will cease to be effective. We recommend that the Authority work with the land use agencies and UDFCD to implement a program of periodic inspections and maintenance of water quality facilities. Work could also include constructing improvements, such as access benches, to reduce costs associated with removing sediment and performing other maintenance operations.

5. **Water Quality Criteria for Individual Site Disposal Systems (ISDSs).** We recommend that the Authority work with Tri-County Health Department and others to modify current criteria for septic tank systems and other ISDSs. Modifications may be necessary to address water quality concerns related to leachate passing relatively untreated through sandy soils and ultimately entering Cherry Creek and the reservoir.

6. **Agricultural Practices.** We recommend that the Authority work with federal and state agencies, and with private farmers and ranchers, to examine, and perhaps modify, agricultural practices that may impact stream and reservoir quality.

Capital Improvement Projects

1. **Lower Cottonwood Creek Improvements.** We recommend that the Authority continue to work toward the implementation of the Lower Cottonwood Creek Improvements over a period of approximately five years.

2. For 1997, two projects are recommended. The first is participating with Arapahoe County and UDFCD in the design and construction of the water quality portion of the detention pond upstream of Peoria Street ($95,000). This commitment was approved by the Board on January 16, 1997. The second project is an initial phase of bioengineered stream stabilization on Cottonwood Creek downstream of Peoria Street, to be implemented by the Authority using a design-build approach ($55,000).

3. **Park Projects.** We recommend that the Authority continue to address water quality concerns within Cherry Creek State Park, through shoreline erosion control, a water quality trail/berm system, work on some of the direct flow drainages, native plant establishment, and consideration of water quality enhancements in the Cherry Creek wetlands upstream of the reservoir.

4. Based on field reconnaissance and discussions with Park staff, the next priority area for shoreline stabilization is adjacent to the east boat ramp. Runoff from the parking lot in this area is creating an erosion/water quality problem that can be addressed through grading and vegetative enhancements. A project in this area is recommended for Spring, 1997 ($80,000).

Other projects recommended for 1997 include native plant establishment to reduce soil loss in the Park ($7,500), the design and construction of a first phase of a water quality trail/berm ($30,000), and an evaluation of water quality needs on tributaries flowing directly into the reservoir ($5,000).

5. **Cherry Creek Corridor Plan Project.** The Cherry Creek Corridor Plan, to be started in February, 1997, will lead to the adoption of a master plan of stormwater quality and quantity improvements. We recommend that the Authority consider participating in the implementation of water quality components of the plan.

6. **Water Quality Retrofit Projects.** We recommend that the Authority consider retrofitting water quality features into selected regional detention facilities upstream of the reservoir. One candidate facility is the Inverness pond on Cottonwood Creek located upstream of Easter Avenue. This large detention pond (approximately 200 acre-feet in total volume) was designed to provide for more than 20 acre-feet of water quality volume, once a water quality outlet is constructed. This water quality volume could be put to use with a relatively simple modification of the Easter Avenue box culvert.

7. **Other Projects.** Opportunities to incorporate water quality features into stormwater quantity projects constructed by others may arise. We recommend that the Authority consider such opportunities on a case-by-case basis.

Monitoring, Investigations, and Studies

1. **Update of Point and Nonpoint Load Estimates and Allowable Loading to Reservoir.** The Authority is currently updating the estimates of point and nonpoint loads and allowable loading to the reservoir that were identified in the 1985 and 1989 versions of the Master Plan. Updated estimates, correlated to existing data, will be useful in determining an appropriate allocation of point and nonpoint sources. Updated estimates are also necessary for accounting for effluent trading credits and for developing appropriate watershed management strategies. The modeling of loads currently underway for the Master Plan Update is to be based on existing data. If, at the conclusion of the initial update, "gaps" in the available data become evident, we recommend that follow-up monitoring or investigations be conducted.

2. **Contributions from Remote Land Application Sites and Septic Systems.** The Authority will soon be undertaking studies to quantify load contributions from remote land application sites and septic systems. The studies will evaluate the movement or assimilation of nutrients from the point they are input to the soil matrix and will estimate the quantity of load that eventually enters Cherry Creek Reservoir from sites at various locations in the watershed. We recommend that results from these studies be used to gain insight into the movement or assimilation of other loads that infiltrate into the soils of the watershed, such as loads contributed by rainfall and stormwater runoff.

3. **Watershed Rainfall/Runoff/Water Quality Monitoring.** We recommend that the Authority expand its current monitoring program to include rainfall/runoff/water quality data on selected tributaries in the watershed. The rainfall/runoff data will help to quantify the infiltration of rainfall and runoff throughout the watershed and within selected stream reaches. Quantifying rates of infiltration is important because

infiltration appears to be a key factor in the assimilation of pollutant loads in the Cherry Creek watershed. Water quality data in selected locations in the watershed will help to verify the loading estimates made in Task 1, above, will help to quantify unit loading rates associated with specific land uses, and will provide a measure of the effectiveness of watershed BMPs.

4. **Stream Stability Evaluation.** We recommend that the Authority undertake an evaluation of long term stream stability for mainstem Cherry Creek and its major tributaries. It is important to understand the creeks' relative stability and predict their natural geomorphic response to estimated future inputs of flow and sediment. The results of this evaluation will help to shape management strategies for mitigating future stream erosion and preserving any water quality benefits associated with the current stream form.

5. **BMP Monitoring.** We recommend that the Authority monitor, on an ongoing basis, selected BMP practices and facilities. This monitoring will provide important data on which BMPs are most effective for reducing loads of concern.

6. **Effluent Trading Accounting Model.** We recommend that the Authority continue to develop and refine an accounting model for tracking effluent trades and credits. The load estimating work discussed in Task 1, above, will provide a foundation for this accounting model. However, incorporating the results from Tasks 2 and 3, above, as well as other data collected in the future, will enhance the accuracy and utility of the accounting model.

References

BRW. 1985. Feasibility Study for the Cherry Creek Basin Drainageway. Prepared for the Cherry Creek Basin Technical Advisory Committee and Parker Jordan Metropolitan District. BRW, Inc. and WRC Engineering, Inc. July 1985.

EPA. 1986. Methodology for Analysis of Detention Basins for Control of Urban Runoff Quality. U.S. Environmental Protection Agency. EPA 440/5-87-001. September 1986.

USGS. 1987. Hydrology of Area 59, Northern Great Plains and Rocky Mountain Coal Provinces, Colorado and Wyoming. Open File Report 85-153. U.S. Geological Survey. Lakewood, Colorado. January 1987.

Appendix A

Photographs of PRFs

OVERALL VIEW

OUTLET VIEW

Shop Creek Water Quality Improvements
CH01RP

OVERALL VIEW

OUTLET VIEW

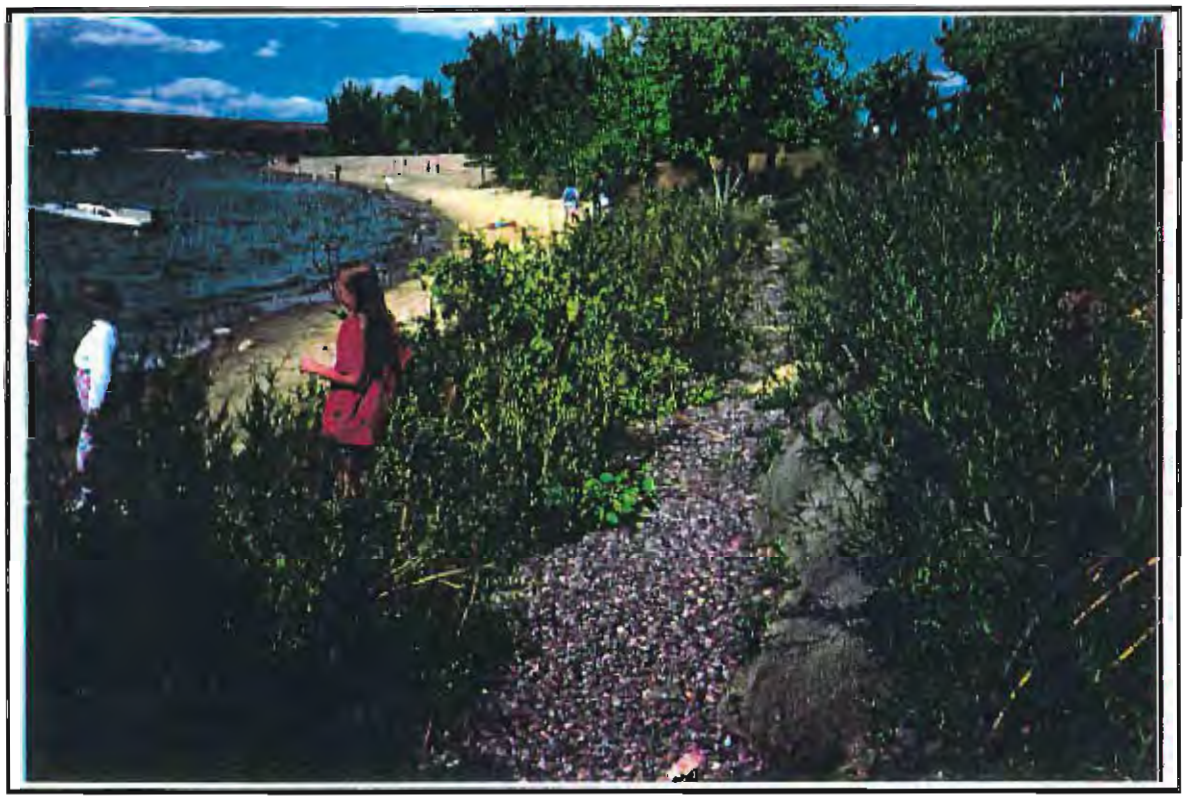
Shop Creek Water Quality Improvements
CH01RP

OVERALL VIEW

OUTLET VIEW

Quincy Outfall Water Quality Improvements
CH02DB

OVERALL VIEW



OUTLET VIEW

East Shade Shelter Shoreline Stabilization Project
CH03

OVERALL VIEW

OUTLET VIEW

Cottonwood Creek Water Quality Improvements
CH04RP

OVERALL VIEW

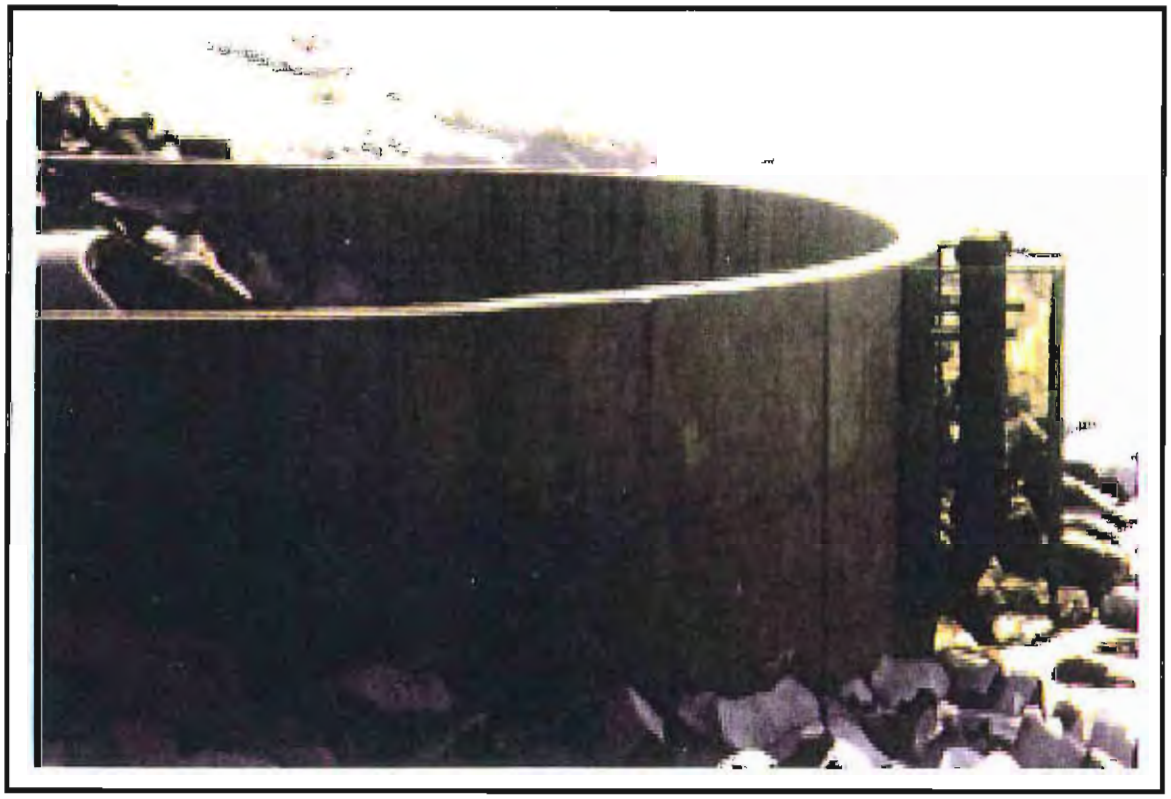
Cherry Creek Vista III Filing 16-A
East Wetland
AR01RP

OVERALL VIEW

OUTLET VIEW

Cherry Creek Vista III Filing 16-A
West Wetland
AR02RP

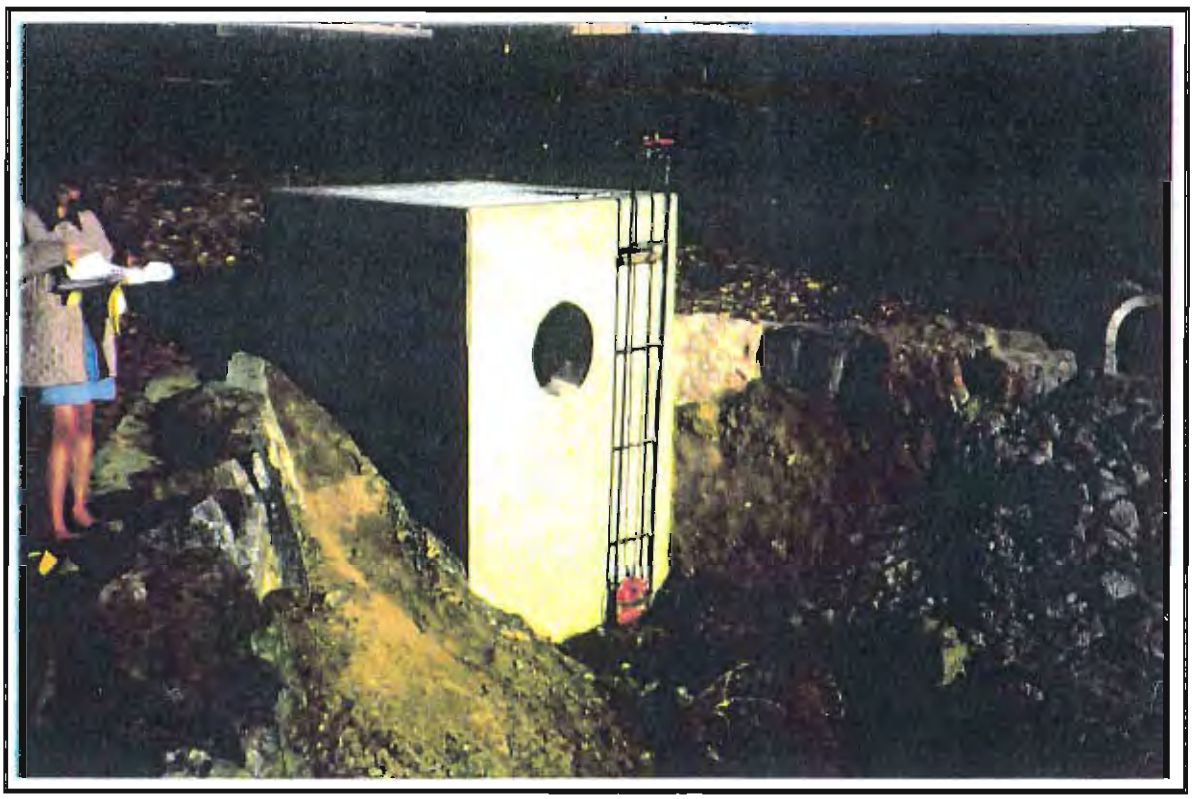
OVERALL VIEW



OUTLET VIEW

Rampart Business Center Filing 6
AR03RP

OVERALL VIEW

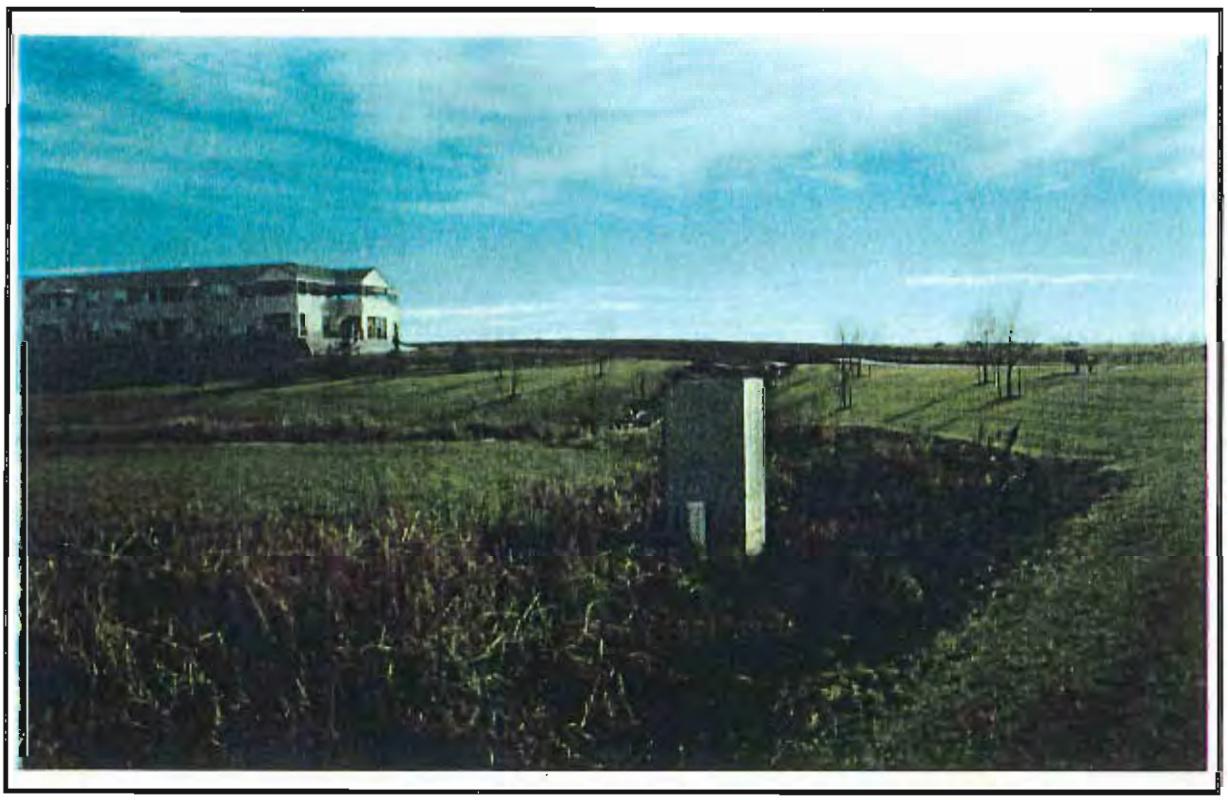


OUTLET VIEW

Lonetree Basin L3, Arapahoe County (AR05DB)

Not yet constructed.

OVERALL VIEW



OUTLET VIEW

Shalom Park
AU01DB

OVERALL VIEW

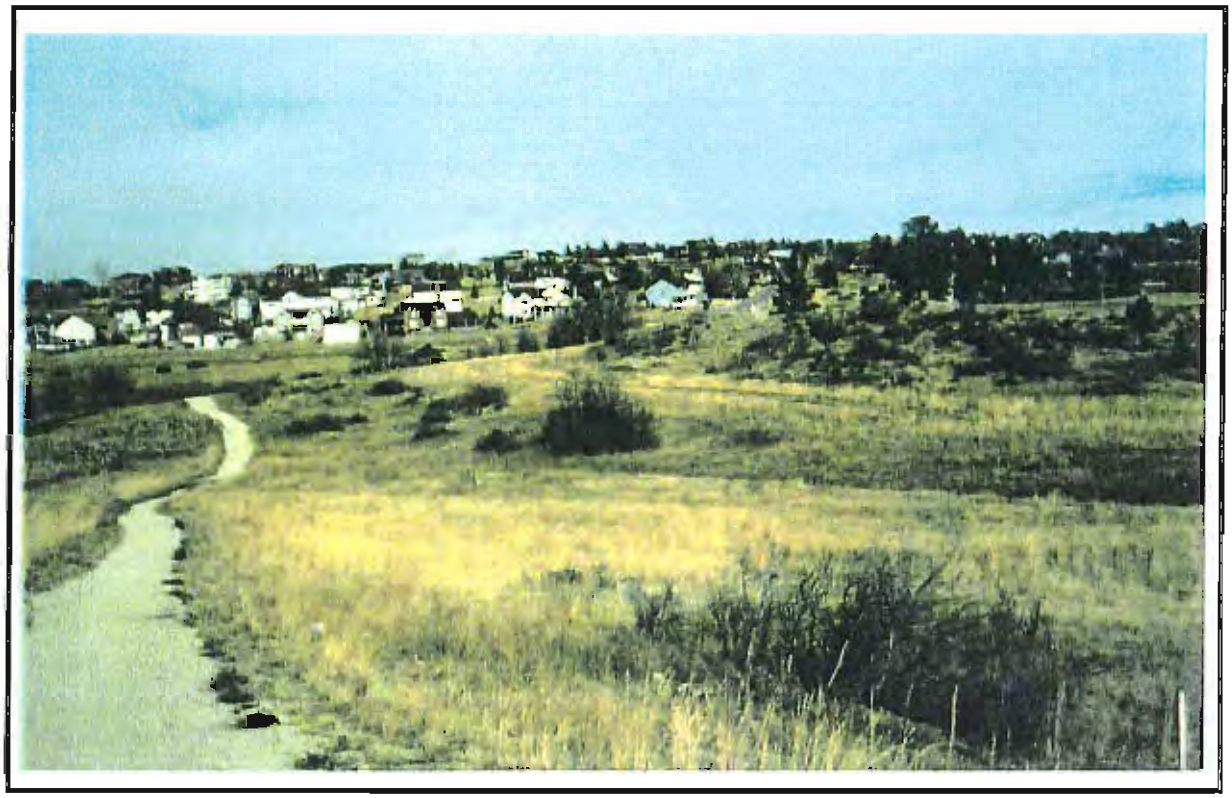
OUTLET VIEW

Cottonwood Subdivision Filing No. 11 Detention Basin
DO01DB

OVERALL VIEW

OUTLET VIEW

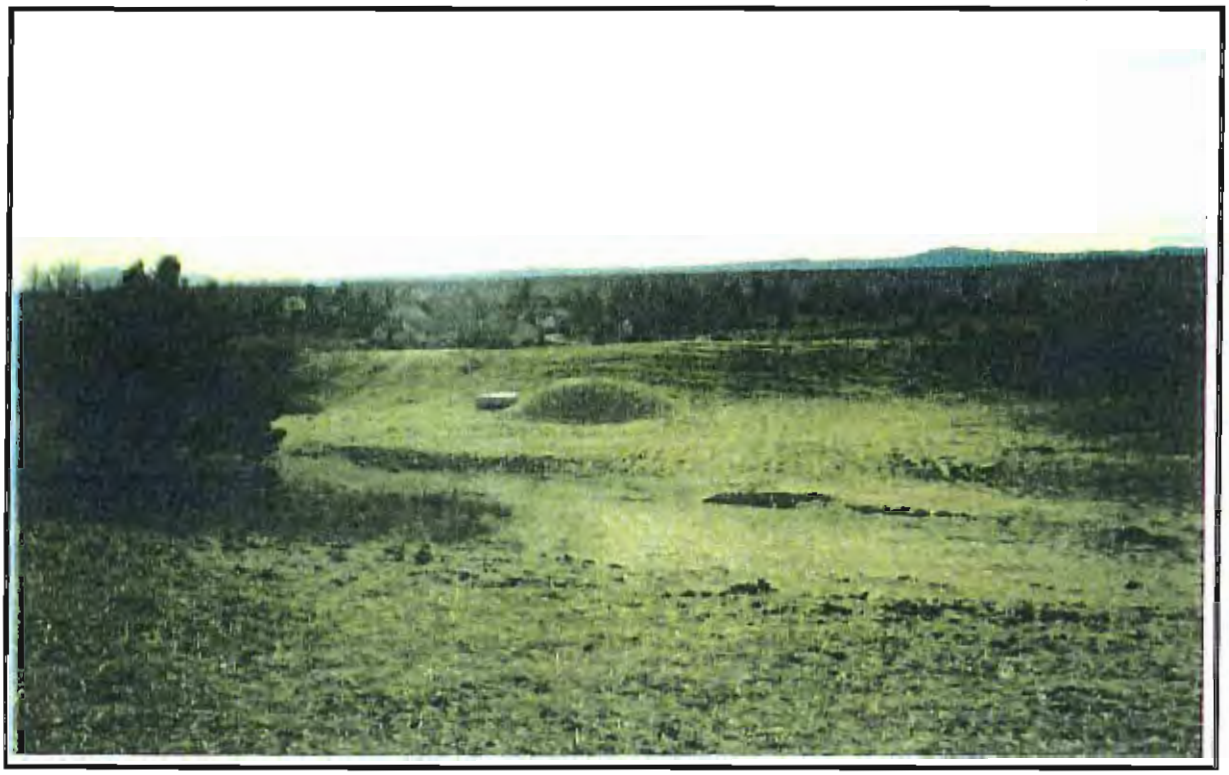
Pinery/High Prairie Farms Filing No. 3, Pond A
DO02DB



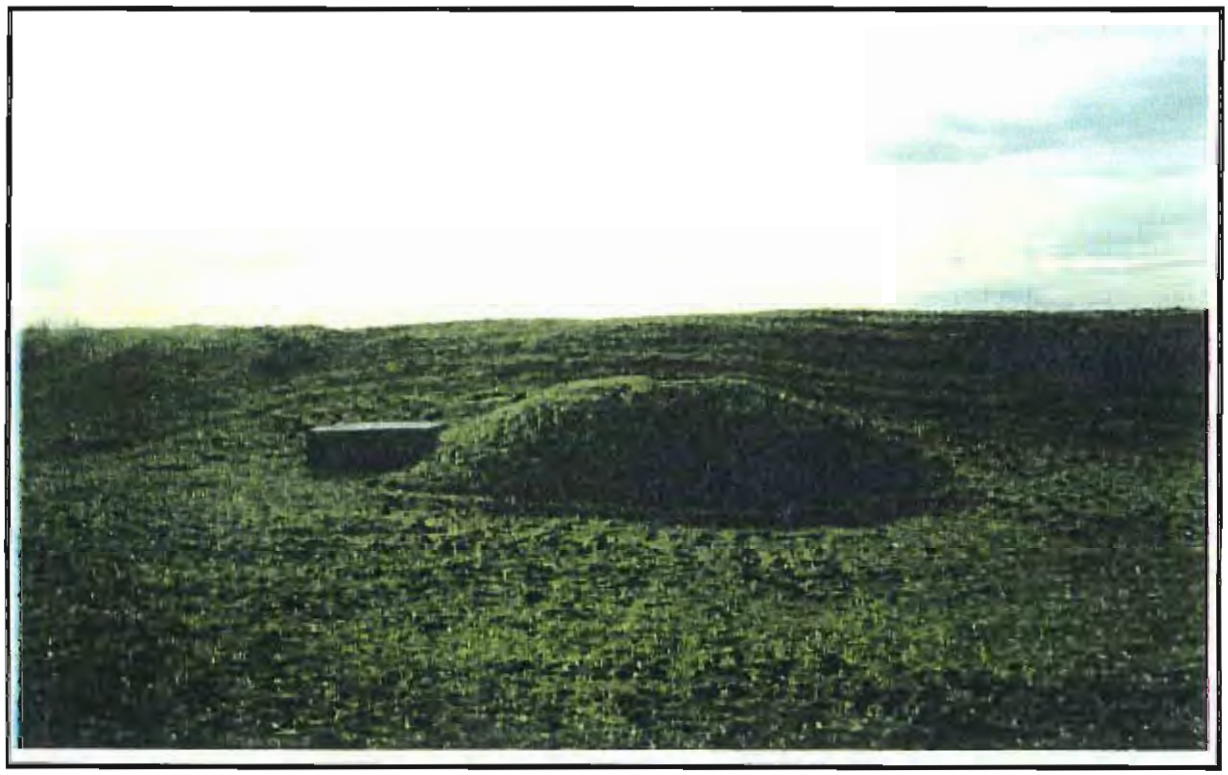
OVERALL VIEW

OUTLET VIEW

Pinery/High Farms Filing No. 3, Pond B
DO03DB



OVERALL VIEW



OUTLET VIEW

Pinery Filing 22, Pond A1
DO04DB

OVERALL VIEW

OUTLET VIEW

Pinery Filing No. 22, Pond A2
DO05DB

OVERALL VIEW

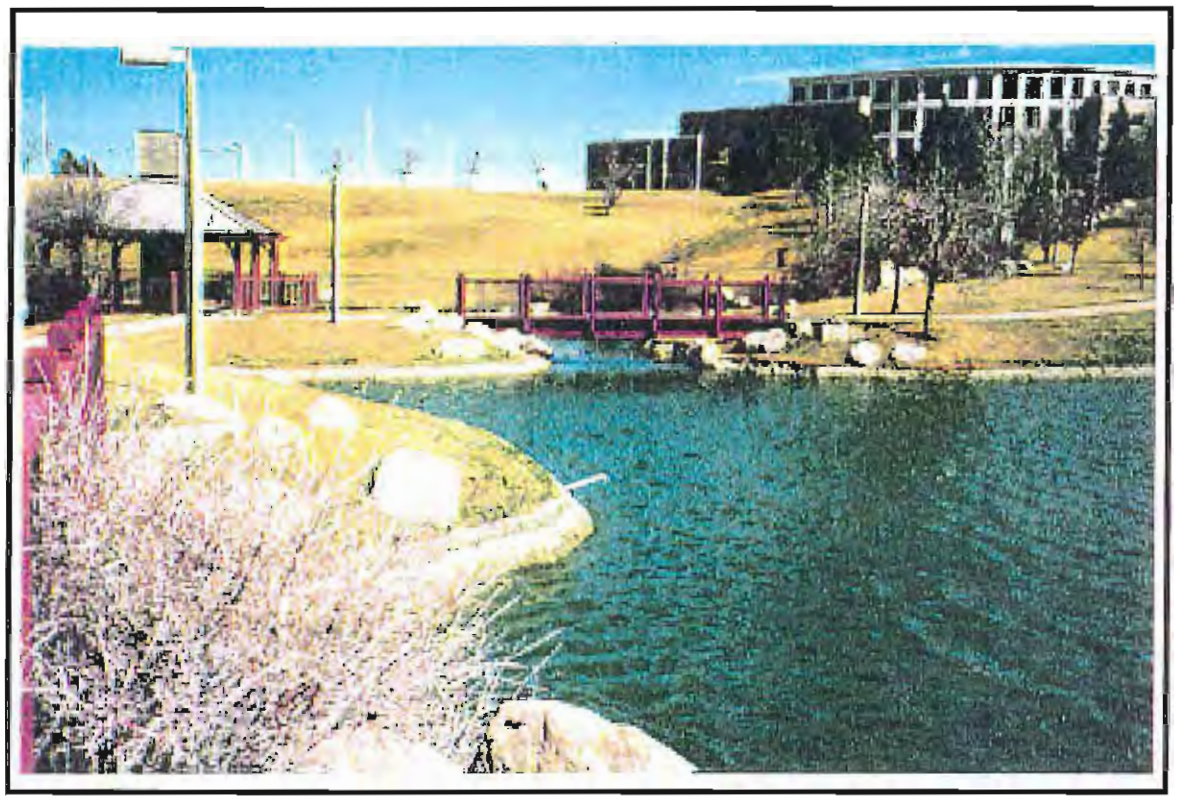
OUTLET VIEW

Pinery Filing No. 22, Pond B1 and Pond B2
DO06DB and DO07DB

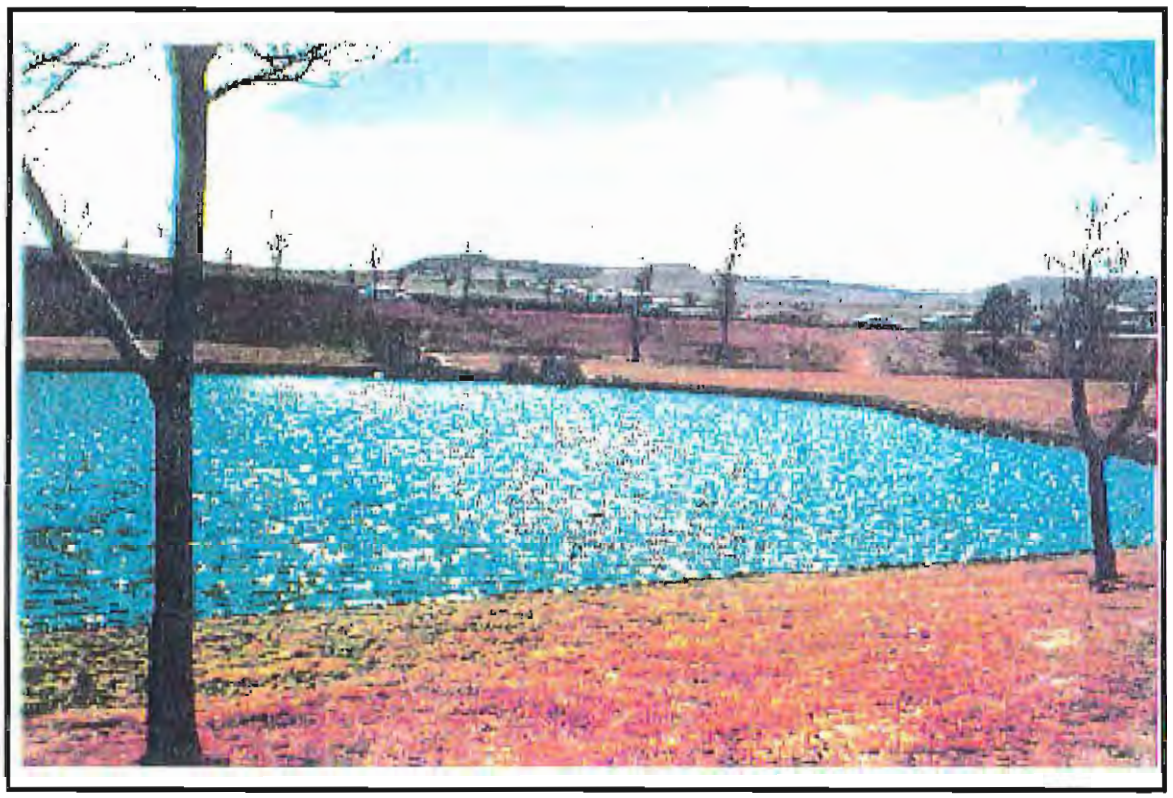
OVERALL VIEW

OUTLET VIEW

The Pinery Filing No. 22, Pond C1
DO08DB

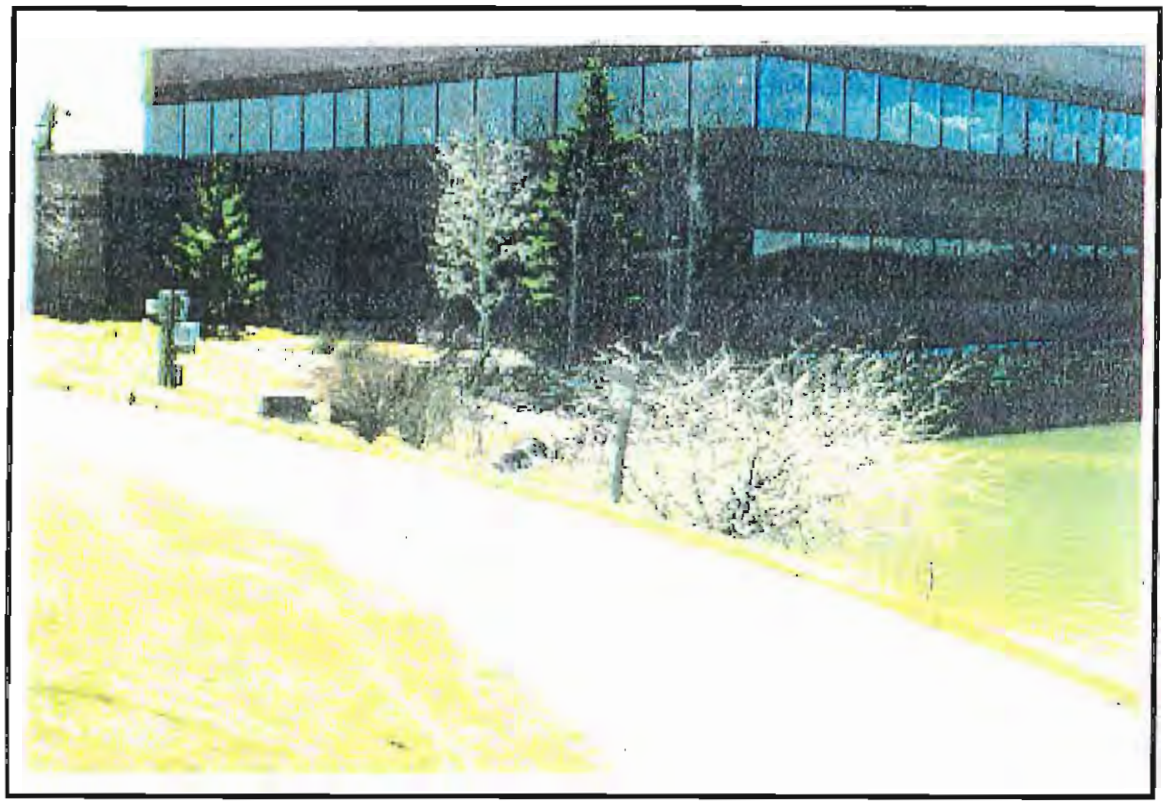


OVERALL VIEW

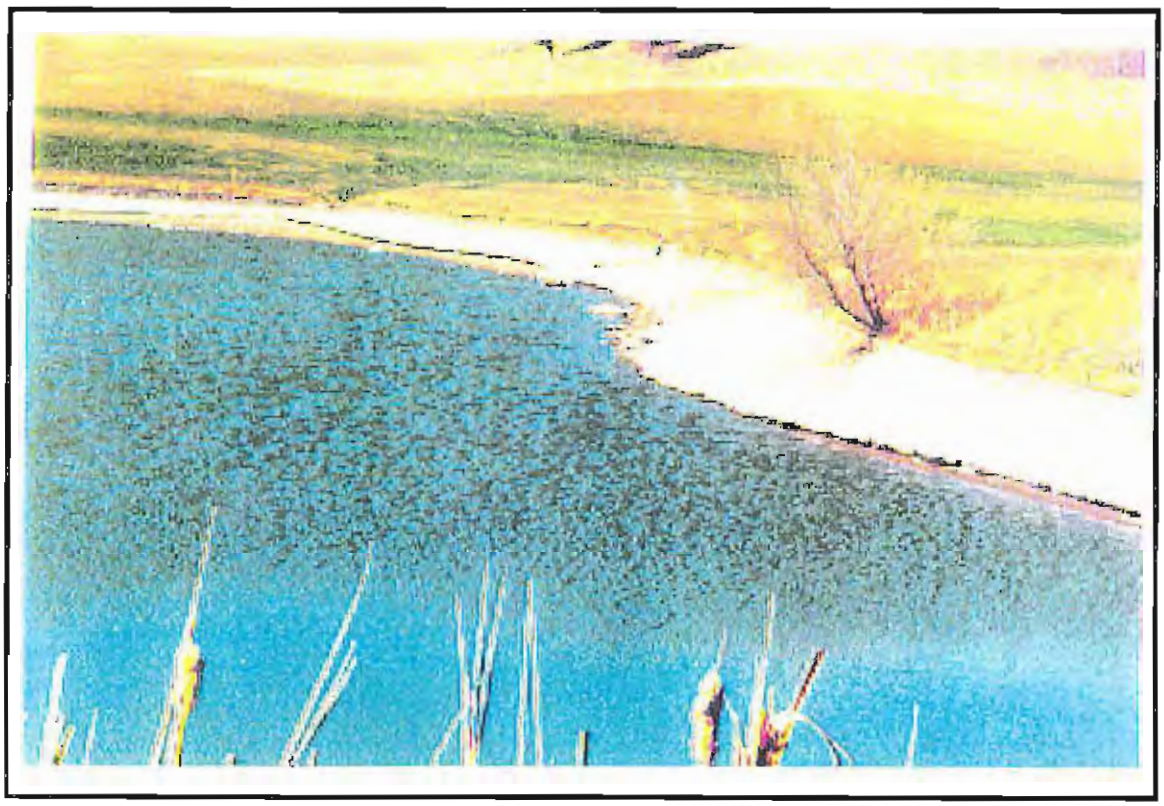


OUTLET VIEW (IN BACKGROUND)

Meridian Pond 1
DO09RP



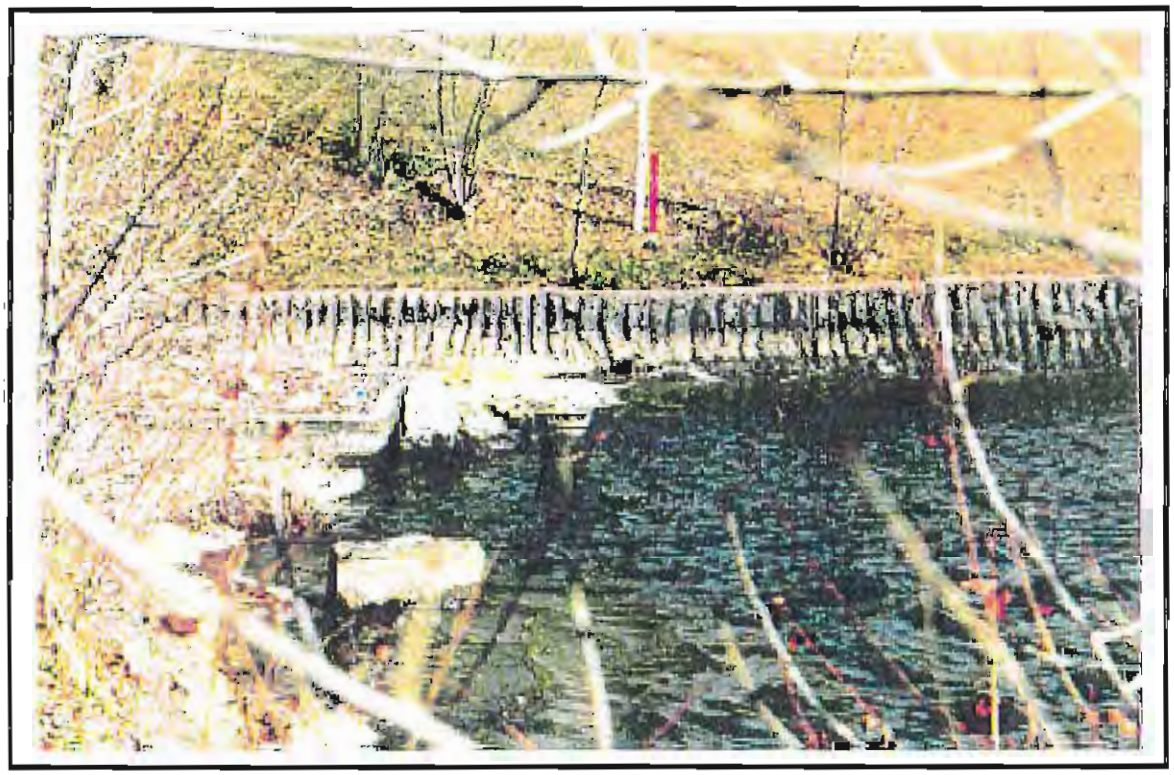
UPSTREAM POND



DOWNSTREAM POND

Meridian Pond 2
DO10RP

TYPICAL SIGNAGE AT MERIDIAN PONDS



OUTLET VIEW

Meridian Pond 3
DO11RP

OVERALL VIEW

OUTLET VIEW

Dayton Farms Detention Basin
GV01RP

OVERALL VIEW

OUTLET VIEW

Greenwood Village Municipal Maintenance Base
GV02DB

OVERALL VIEW

OUTLET VIEW

Parker United Methodist Church
1st Detention Pond from North
PA01DB

OVERALL VIEW

OUTLET VIEW

Parker United Methodist Church
2nd Detention Pond from North
PA02DB

OVERALL VIEW

OUTLET VIEW

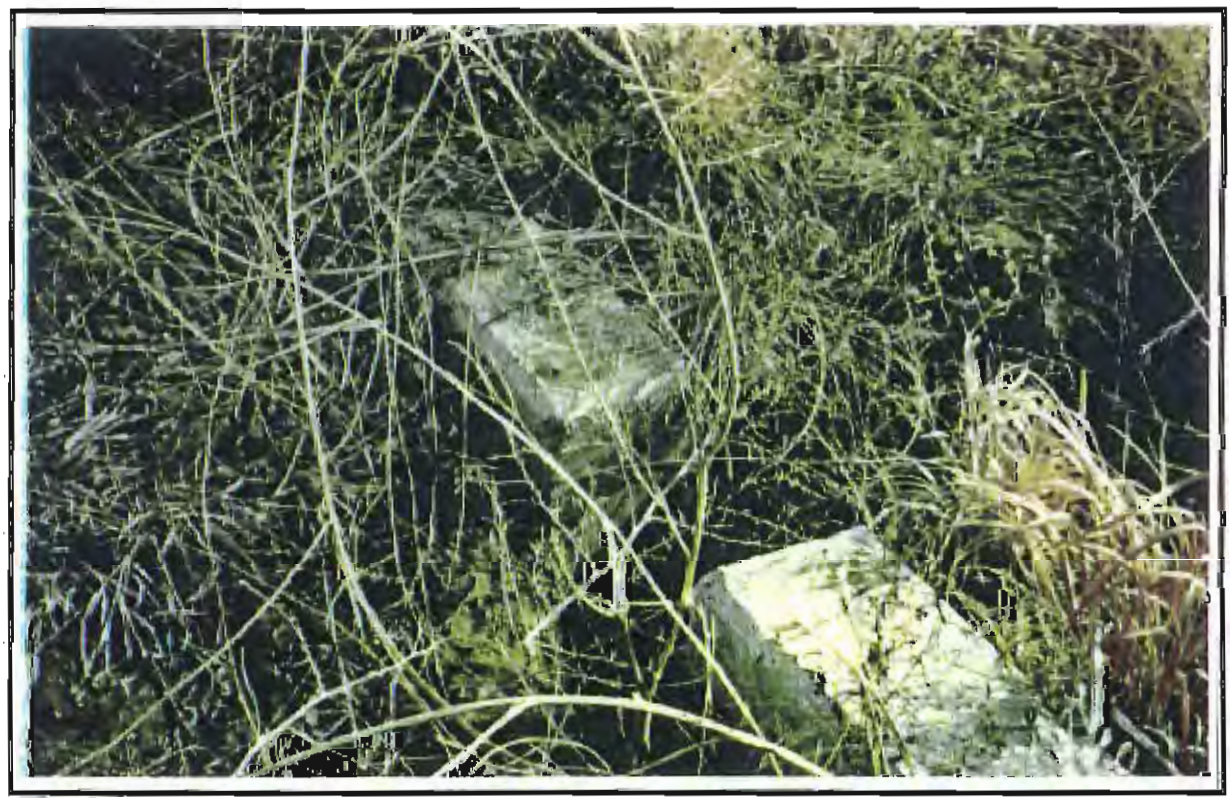
Parker United Methodist Church
3rd Detention Pond from North
PA03DB

OVERALL VIEW

OUTLET VIEW

Parker Vista
PA04DB

OVERALL VIEW



OUTLET VIEW

Parker Vista (North Detention Pond)
PA05DB

OVERALL VIEW

OUTLET VIEW

Canterbury Crossing
PA06DB

OVERALL VIEW

OUTLET VIEW

Willow Ridge Filing 1
PA07DB

OVERALL VIEW

OUTLET VIEW

Willow Ridge Filing 2
PA08DB

OVERALL VIEW

OUTLET VIEW

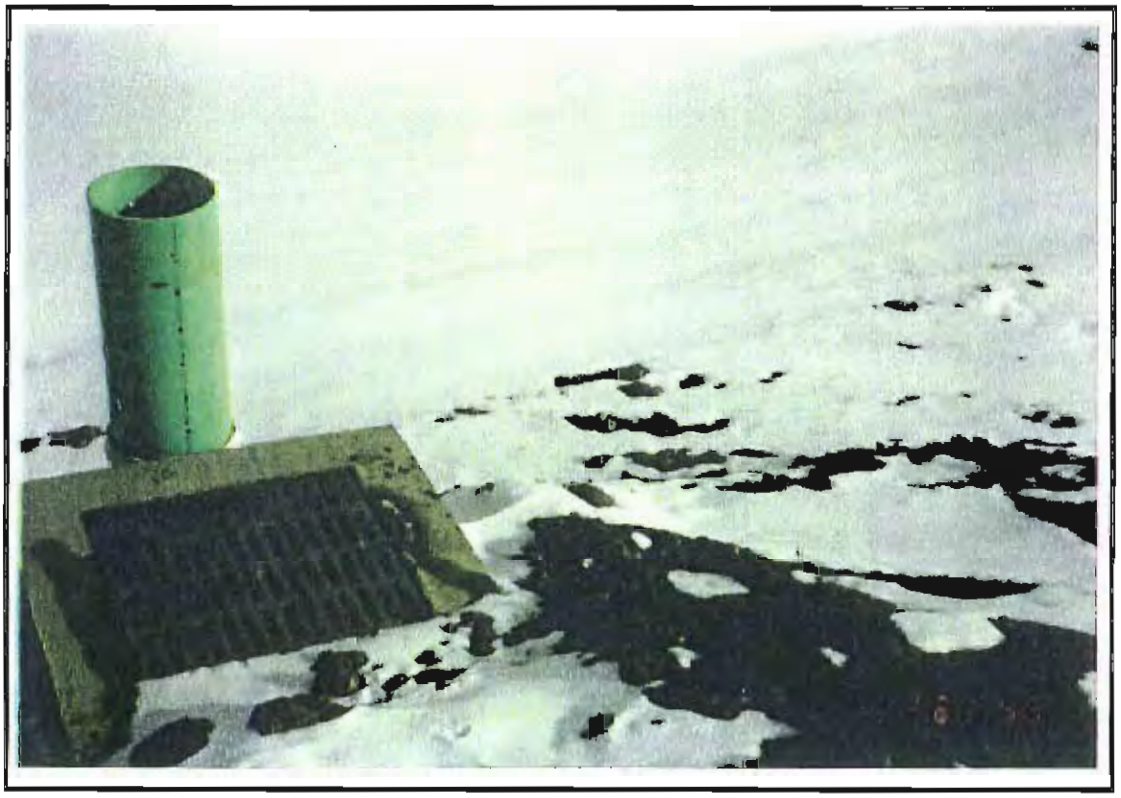
Willow Park West
PA09DB

OVERALL VIEW

OUTLET VIEW

Willow Park East
PA10DB

OVERALL VIEW



OUTLET VIEW

Parker Marketplace Phase 2 Detention Pond
PA11DB

OVERALL VIEW

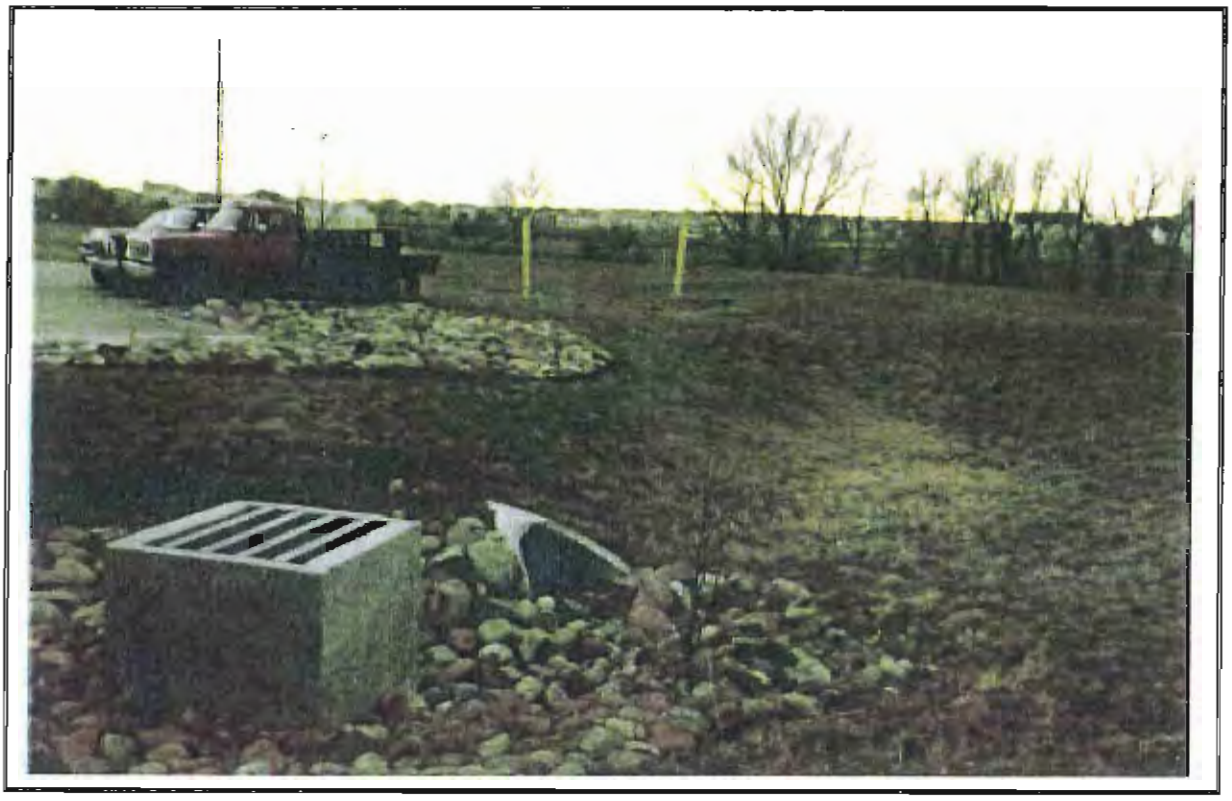
OUTLET VIEW

Bradbury Ranch
PA12DB

OVERALL VIEW

OUTLET VIEW

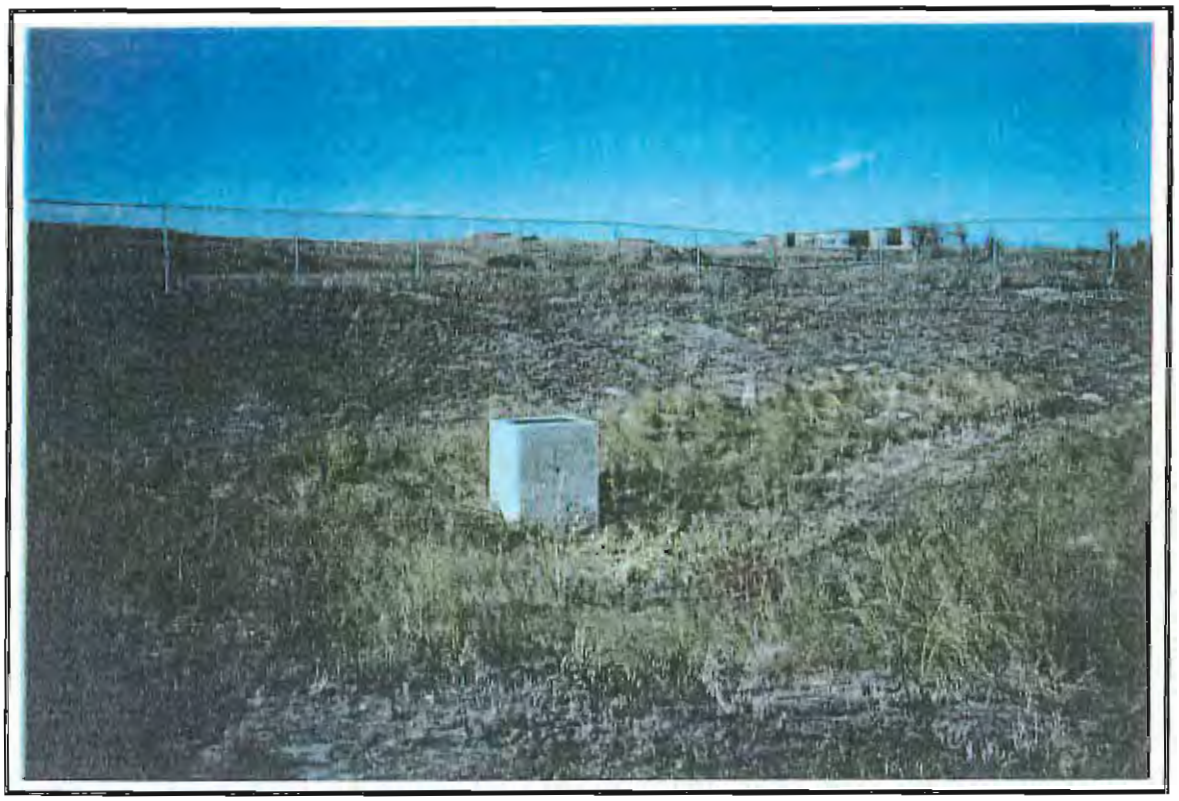
Baldwin Pond
PA13DB



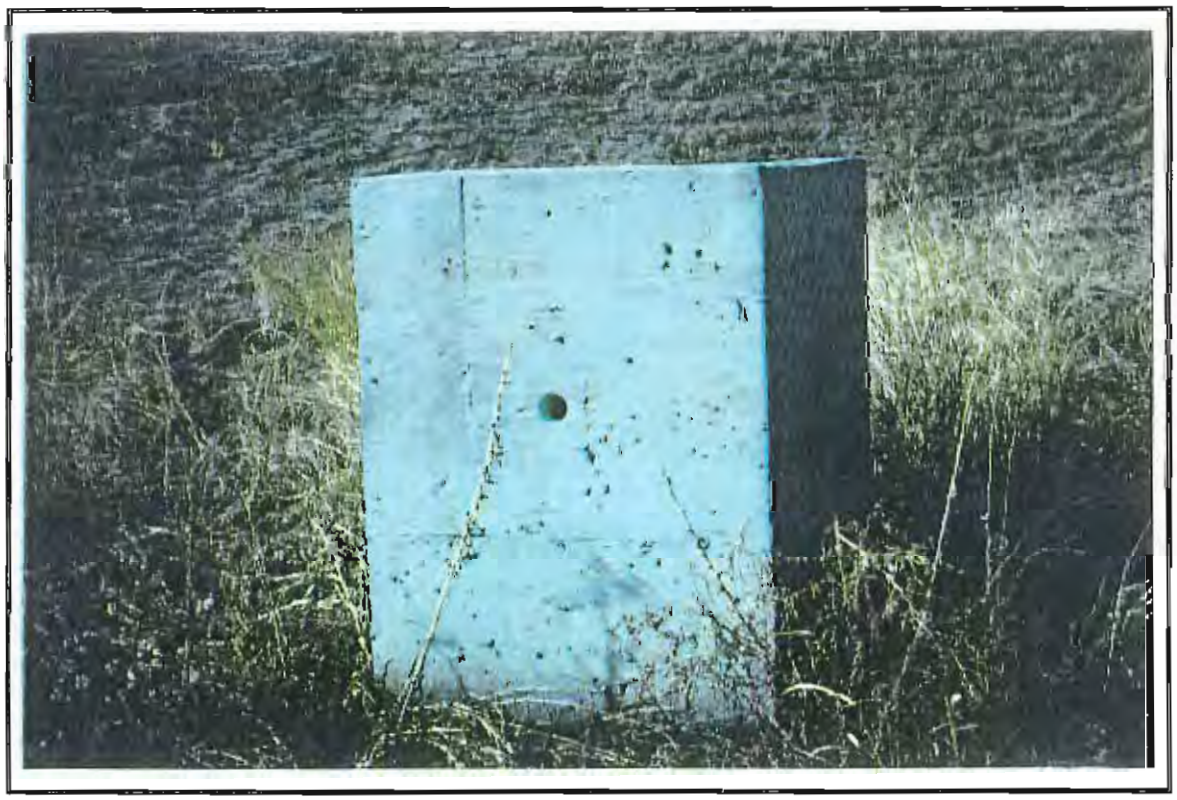
OVERALL VIEW

OUTLET VIEW

Joint Use Facility Pond 1
PA14DB



OVERALL VIEW



OUTLET VIEW

Joint Use Facility Pond 2
PA15DB

OVERALL VIEW

OUTLET VIEW

Clarke Farms Detention Pond
PA16DB

Appendix B

Initial PRF Data Base

Retention Basin

19-May-97

Name of PRF: CH01RP **Type of BMP:** Water Quality Detention Pond

Description: Shop Creek System

BMP Design: Designed as a Water Quality Facility.

Date BMP put into service: 9/1/89 **Number of Inflow Points:** 2

Watershed Area: 520 Acres **% of Total Watershed that is Impervious:** 39.00%

Types and designs of Outlets:

WQ Outlet:12"x6" Orifice

Permanent Pool Features

Volume of Permanent Pool: 4.6 Ac-ft **Permanent Pool Surface Area:** 1.3 Acres

Permanent Pool Length: 570 Feet **Littoral Zone Surface Area:** 0.2 Ac

Water Quality Features

Water Quality Surcharge Detention Volume: 9.1 Ac-ft

Water Quality Detention Surface Area: 2.1 Ac

Water Quality Detention Basin's Length: 570 Ft^2

Brim-full Emptying Time: 36 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Forebay Volume: 0.4 Ac-ft **Forebay Surface Area:** 0.1 Acres

Flood Control Features

Flood Control Volume above the Water quality Detention Volume: Ac-ft

Flood Return Periods:

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: Ft^2 **Media Filter Surface:**

Number of Layers: 0

Types of Filter Media:

Depth of Each Layer:

Comments: Water Quality Discharge= 3.06 cfs (Discharge= WQ Volume/Drain Time). Water quality detention facility is followed by a series of wetland areas (5.0 Ac surface area).

Detention Basin

19-May-97

Name of PRF: CH02DB **Type of BMP:** Water Quality Pond

Description: Quincy Outfall Project

BMP Design: Designed as a Water Quality Facility.

Date BMP Put Into Service: 1/1/96 **Number of Inflow Points:** 1

Watershed Area: 530 Acres **% of Total Watershed that is Impervious:** 48.00%

Types and designs of Outlets:
WQ Outlet: 6" x 10" Orifice

Water Quality Features

Water Quality Detention Volume: 8.8 Ac-ft

Water Quality Detention Surface Area: 4.4 Acres

Water Quality Detention Basin's Length: 900 Feet

Detention Basin's Bottom Area: 1.4 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0.2 Ac-ft **Forebay Surface Area:** 0.1 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge= 3.33 cfs (Approximated based Volume/Drain Time). Additional 3.0 Acre-Ft provided for sediment storage.

Retention Basin

19-May-97

Name of PRF: CH04RP **Type of BMP:** Water Quality Detention Pond

Description: Cottonwood Creek Water Quality Improvements

BMP Design: Designed as a water quality facility.

Date BMP put into service: **Number of Inflow Points:** 1

Watershed Area: 7532.3 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

WQ Outlet: Multiple Orifices and Weir (10"x6" orifice, 24"x6" orifice, 5' weir).

Permanent Pool Features

Volume of Permanent Pool: 1.6 Ac-ft **Permanent Pool Surface Area:** 0.8 Acres

Permanent Pool Length: 1200 Feet **Littoral Zone Surface Area:** 0.8 Ac

Water Quality Features

Water Quality Surcharge Detention Volume: 22 Ac-ft

Water Quality Detention Surface Area: 11 Ac

Water Quality Detention Basin's Length: 1200 Ft^2

Brim-full Emptying Time: 48 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Flood Control Features

Flood Control Volume above the Water quality Detention Volume: 0 Ac-ft

Flood Return Periods:

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2 **Media Filter Surface:**

Number of Layers: 0

Types of Filter Media:

Depth of Each Layer:

Comments: Additional 13 Acre-Ft provided for sediment storage. Water Quality Discharge= 5.55 cfs (Discharge = WQ Vol/Drain Time)

Retention Basin

19-May-97

Name of PRF: AR01RP **Type of BMP:** Retention Pond

Description: Cherry Creek Vista III Filing 16-A East Wetland Pond

BMP Design: Designed to detain the 100-Yr storm event.

Date BMP put into service: **Number of Inflow Points:** 1

Watershed Area: 28.46 Acres **% of Total Watershed that is Impervious:**

Types and designs of Outlets:

2-Yr and 100-Yr Outlet: 15.85' Long Spillway

Permanent Pool Features

Volume of Permanent Pool: 1.4 Ac-ft **Permanent Pool Surface Area:** 0.85 Acres

Permanent Pool Length: 224 Feet **Littoral Zone Surface Area:** 0 Ac

Water Quality Features

Water Quality Surcharge Detention Volume: 0 Ac-ft

Water Quality Detention Surface Area: 0 Ac

Water Quality Detention Basin's Length: 0 Ft^2

Brim-full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Flood Control Features

Flood Control Volume above the Water quality Detention Volume: 2.7 Ac-ft

Flood Return Periods: 100-Yr

10-Yr Peak Discharge: cFs **100-Yr Peak Discharge:** cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2 **Media Filter Surface:**

Number of Layers: 0

Types of Filter Media:

Depth of Each Layer:

Comments: 2-Yr Discharge=29.27 cfs (Approximated from drainage plans.) Basin bottom consists of wetlands. Volume of permanent pool and flood control were estimated from drainage plans. Note: Flood control volume is volume above the "Permanent Pool Volume".

Retention Basin

19-May-97

Name of PRF: AR02RP **Type of BMP:** Retention Pond

Description: Cherry Creek Vista III Filing 16-A West Wetland Pond

BMP Design: Designed to detain 100-Yr Storm event.

Date BMP put into service: **Number of Inflow Points:** 1

Watershed Area: 20.63 Acres **% of Total Watershed that is Impervious:**

Types and designs of Outlets:

2-Yr and 100-Yr Outlet: 19.75' Long Spillway

Permanent Pool Features

Volume of Permanent Pool: 6.8 Ac-ft **Permanent Pool Surface Area:** 1.91 Acres

Permanent Pool Length: 256 Feet **Littoral Zone Surface Area:** 0 Ac

Water Quality Features

Water Quality Surcharge Detention Volume: 0 Ac-ft

Water Quality Detention Surface Area: 0 Ac

Water Quality Detention Basin's Length: 0 Ft^2

Brim-full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Flood Control Features

Flood Control Volume above the Water quality Detention Volume: 4.75 Ac-ft

Flood Return Periods: 100-Yr

10-Yr Peak Discharge: cFs **100-Yr Peak Discharge:** cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2 **Media Filter Surface:**

Number of Layers: 0

Types of Filter Media:

Depth of Each Layer:

Comments: 2-Yr Discharge= 33.19 cfs (Approximated from drainage plans.) Basin bottom consists of wetlands. Volume of permanent pool and flood control were estimated from drainage plans. Note: Flood control volume is the volume above the permanent pool volume.

Retention Basin

19-May-97

Name of PRF: AR03RP **Type of BMP:** Retention Pond

Description: Rampart Business Center Filing No. 6 Pond No. 1 and Pond No. 2 (Lot1, Block 1)

BMP Design: Designed as a water quality and 100-Yr detention basin.

Date BMP put into service: **Number of Inflow Points:** 0

Watershed Area: 143.65 Acres **% of Total Watershed that is Impervious:**

Types and designs of Outlets:

WQ Outlet: Riser; 10-Yr Outlet: ;100-Yr Outlet:

Permanent Pool Features

Volume of Permanent Pool: 0.2 Ac-ft **Permanent Pool Surface Area:** 0.1 Acres

Permanent Pool Length: 70 Feet **Littoral Zone Surface Area:** 0 Ac

Water Quality Features

Water Quality Surcharge Detention Volume: 1.22 Ac-ft

Water Quality Detention Surface Area: 0.57 Ac

Water Quality Detention Basin's Length: 0 Ft^2

Brim-full Emptying Time: 12 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Flood Control Features

Flood Control Volume above the Water quality Detention Volume: 0 Ac-ft

Flood Return Periods:

10-Yr Peak Discharge: cFs **100-Yr Peak Discharge:** cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2 **Media Filter Surface:**

Number of Layers: 0

Types of Filter Media:

Depth of Each Layer:

Comments: Water Quality Discharge=1.23 cfs (Approximated from a 12 hour drain time.)

Retention Basin

19-May-97

Name of PRF: AR04RP **Type of BMP:** 100-Yr Retention Pond

Description: Inverness Filing 17 located in Inverness Business Park(northeast corner of Dry Creek & Clinton)

BMP Design: Designed to detain 10- and 100-Yr storm event.

Date BMP put into service: **Number of Inflow Points:** 3

Watershed Area: 33.45 Acres **% of Total Watershed that is Impervious:**

Types and designs of Outlets:

10-Yr Outlet- Orifice ; 100-Yr Outlet: Weir

Permanent Pool Features

Volume of Permanent Pool: 1.7 Ac-ft **Permanent Pool Surface Area:** 23597 Acres

Permanent Pool Length: Feet **Littoral Zone Surface Area:** 0 Ac

Water Quality Features

Water Quality Surcharge Detention Volume: 0 Ac-ft

Water Quality Detention Surface Area: 0 Ac

Water Quality Detention Basin's Length: 0 Ft^2

Brim-full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** Acres

Flood Control Features

Flood Control Volume above the Water quality Detention Volume: 5 Ac-ft

Flood Return Periods: 10-Yr and 100-Yr

10-Yr Peak Discharge: cFs **100-Yr Peak Discharge:** cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2 **Media Filter Surface:**

Number of Layers: 0

Types of Filter Media:

Depth of Each Layer:

Comments: Permanent pool volume and surface area estimated from drainage plans.

Detention Basin

19-May-97

Name of PRF: AR05DB

Type of BMP: Water Quality and 100-Yr Detention Basin

Description: Lonetree Pond L3

BMP Design: Designed as a Water Quality and 100-Yr detention facility.

Date BMP Put Into Service:

Number of Inflow Points: 1

Watershed Area: 975 Acres

% of Total Watershed that is Impervious:

Types and designs of Outlets:

WQ Outlet: 24" Elbow (No perforations) ; 100-Yr Outlet: Overflow Weir

Water Quality Features

Water Quality Detention Volume:	17.1 Ac-ft		
Water Quality Detention Surface Area:	6.3 Acres		
Water Quality Detention Basin's Length:	0 Feet		
Detention Basin's Bottom Area:	0 Acres		
Brim full Emptying Time:	12 Hrs	**Half Brim-full Emptying Time:**	0 Hrs
Bottom Stage Volume:	0 Acres	**Bottom Stage Surface Area:**	0 Acres
Forebay Volume:	0 Ac-ft	**Forebay Surface Area:**	0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume:	30.3 Ac-ft	**Flood Return Periods:**	100-Yr
10-Yr Peak Discharge:	cFs	**100-Yr Peak Discharge:**	1535 cFs

Media Filter Features

Media Filter Surface Area:	0 Ft^2
Media Filter Surface:	
Number of Layers:	0
Depth of Each Layer:	
Types of Filter Media:	

Comments: WQ Discharge= 34 cfs. The total flood control volume of 30.3 acre-ft includes the water quality volume of 17.1 acre-ft.

Detention Basin

19-May-97

Name of PRF: AU01DB **Type of BMP:** Water Quality and 100-Yr Detention Basin

Description: Shalom Park Subdivision Detention Basin

BMP Design: Designed as a Water Quality and 100-Yr detention basin.

Date BMP Put Into Service: 12/1/91 **Number of Inflow Points:** 2

Watershed Area: 105.6 Acres **% of Total Watershed that is Impervious:** 49.00%

Types and designs of Outlets:

WQ Outlet: 10" Pipe w/1" holes; 100-Yr Outlet: 4'0" Wide x 3'0" Deep Weir Box

Water Quality Features

Water Quality Detention Volume: 2.2 Ac-ft

Water Quality Detention Surface Area: 1.05 Acres

Water Quality Detention Basin's Length: 165 Feet

Detention Basin's Bottom Area: 0.01 Acres

Brim full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 10.5 Ac-ft **Flood Return Periods:** 2-Yr and 100-Yr

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 101 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge= 1.3 cfs, When the City of Aurora deems necessary, the water quality filtration basin will be built.

Detention Basin

19-May-97

Name of PRF: DO01DB **Type of BMP:** Water Quality and 100-Yr Detention Basin

Description: Cottonwood Subdivision Filing No. 11 Detention Pond

BMP Design: Designed to detain 100-Yr Storm event.

Date BMP Put Into Service: **Number of Inflow Points:** 3

Watershed Area: 259.75 Acres **% of Total Watershed that is Impervious:**

Types and designs of Outlets:

WQ Outlet: 4" Perf PVC Underdrain Collection System; 10-Yr Storm Outlet- 2'x3.8' Orifice; 100-Yr Storm Outlet-6.40' long weir.

Water Quality Features

Water Quality Detention Volume: 1.81 Ac-ft

Water Quality Detention Surface Area: 1.88 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0 Acres

Brim full Emptying Time: 12 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 16 Ac-ft **Flood Return Periods:** 10-Yr and 100-Yr

10-Yr Peak Discharge: cFs **100-Yr Peak Discharge:** cFs

Media Filter Features

Media Filter Surface Area: Ft^2

Media Filter Surface:

Number of Layers:

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge = 0.55 cfs. (Approximated based on WQ Vol/Drain Time.) The Water Quality Capture Volume designed only to treat 145 acres of single family homes.

Detention Basin

19-May-97

Name of PRF: DO02DB **Type of BMP:** Water Quality and 100-Yr Detention Basin

Description: The Pinery/High Prairie Farms Filing No. 3, Detention Pond A

BMP Design: Designed to detain 100-Yr Storm event.

Date BMP Put Into Service: **Number of Inflow Points:** 1

Watershed Area: 42.94 Acres **% of Total Watershed that is Impervious:**

Types and designs of Outlets:

WQ Outlet: Riser Pipe w/3/8" holes;10-Yr Storm Outlet-15" RCP; 100-Yr Storm Outlet- 19' long weir

Water Quality Features

Water Quality Detention Volume: 0.48 Ac-ft

Water Quality Detention Surface Area: 0.24 Acres

Water Quality Detention Basin's Length: 110 Feet

Detention Basin's Bottom Area: 0.022 Acres

Brim full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0.7 Ac-ft **Flood Return Periods:** 10-Yr and 100-Yr

10-Yr Peak Discharge: cFs **100-Yr Peak Discharge:** cFs

Media Filter Features

Media Filter Surface Area: 1514 Ft^2

Media Filter Surface: Horizontal

Number of Layers: 2

Depth of Each Layer: Layer 1: 12"; Layer 2: 36"

Types of Filter Media: Layer 1: Sand; Layer 2: Gravel

Comments: WQ Discharge= 0.30 cfs. Detention basin discharges to media filter just downstream of outlet.

Detention Basin

19-May-97

Name of PRF: DO03DB **Type of BMP:** Water Quality and 100-Yr Detention Basin

Description: The Pinery/High Prairie Farms Filing 3, Detention Pond B

BMP Design: Designed to detain 100-Yr Storm event.

Date BMP Put Into Service: **Number of Inflow Points:** 1

Watershed Area: 44.78 Acres **% of Total Watershed that is Impervious:**

Types and designs of Outlets:

WQ Outlet: 4" Perf Pipe w/3/8" holes; 10-Yr Outlet: 6"x3'4" Orifice; 100-Yr Outlet: 18' long weir

Water Quality Features

Water Quality Detention Volume: 0.49 Ac-ft

Water Quality Detention Surface Area: 0.33 Acres

Water Quality Detention Basin's Length: 130 Feet

Detention Basin's Bottom Area: 0 Acres

Brim full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0.8 Ac-ft **Flood Return Periods:** 10-Yr and 100-Yr

10-Yr Peak Discharge: cFs **100-Yr Peak Discharge:** cFs

Media Filter Features

Media Filter Surface Area: 1650 Ft^2

Media Filter Surface: Horizontal

Number of Layers: 2

Depth of Each Layer: Layer 1: 12"; Layer 2: 36"

Types of Filter Media: Layer 1: Sand; Layer 2: Gravel

Comments: WQ Discharge= 0.33 cfs. Detention basin discharges to media filter just downstream.

Detention Basin

19-May-97

Name of PRF: DO04DB **Type of BMP:** Water Quality and 100-Yr Detention Basin

Description: The Pinery Filing No. 22, Detention Pond A1

BMP Design: Designed to detain 100-Yr Storm event.

Date BMP Put Into Service: **Number of Inflow Points:** 1

Watershed Area: 18.88 Acres **% of Total Watershed that is Impervious:**

Types and designs of Outlets:

WQ Outlet: Riser Pipe; 10-Yr Outlet: 6" pipe; 100-Yr Outlet: 8' long weir

Water Quality Features

Water Quality Detention Volume: 0.06 Ac-ft

Water Quality Detention Surface Area: 0.11 Acres

Water Quality Detention Basin's Length: 95 Feet

Detention Basin's Bottom Area: 0.024 Acres

Brim full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0.27 Ac-ft **Flood Return Periods:** 10-Yr and 100-Yr

10-Yr Peak Discharge: cFs **100-Yr Peak Discharge:** cFs

Media Filter Features

Media Filter Surface Area: 230 Ft^2

Media Filter Surface: Horizontal

Number of Layers:

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge= 0.05 cfs.

Detention Basin

19-May-97

Name of PRF: DO05DB **Type of BMP:** Water Quality and 100-Yr Detention Basin

Description: The Pinery Filing No. 22, Detention Pond A2

BMP Design: Designed to detain 100-Yr Storm event.

Date BMP Put Into Service: **Number of Inflow Points:** 2

Watershed Area: 39.02 Acres **% of Total Watershed that is Impervious:**

Types and designs of Outlets:

WQ Outlet: Riser Perf Pipe; 10-Yr Outlet: 16"x16" Orifice; 100-Yr Outlet: 68" long weir.

Water Quality Features

Water Quality Detention Volume: 0.29 Ac-ft

Water Quality Detention Surface Area: 0.45 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0.065 Acres

Brim full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 1.68 Ac-ft **Flood Return Periods:** 10-Yr and 100-Yr

10-Yr Peak Discharge: cFs **100-Yr Peak Discharge:** cFs

Media Filter Features

Media Filter Surface Area: 1266 Ft^2

Media Filter Surface: Horizontal

Number of Layers:

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge = 0.25 cfs.

Detention Basin

19-May-97

Name of PRF: DO06DB **Type of BMP:** Water Quality Detention Basin

Description: The Pinery Filing No. 22, Detention Pond B1

BMP Design: Designed as a Water Quality facility.

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 16.02 Acres **% of Total Watershed that is Impervious:**

Types and designs of Outlets:
WQ Outlet: Riser Perf PVC w/3/8" holes

Water Quality Features

Water Quality Detention Volume: 0.1 Ac-ft

Water Quality Detention Surface Area: 0.12 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0.007 Acres

Brim full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:** 0

10-Yr Peak Discharge: cFs **100-Yr Peak Discharge:** cFs

Media Filter Features

Media Filter Surface Area: Ft^2

Media Filter Surface:

Number of Layers:

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge= 0.06 cfs. Pond B1 and Pond B2 form a system of detention basin with Pond B1 upstream of Pond B2. Pond B1 serves as a water quality capture pond while Pond B2 serves as a flood control pond.

Detention Basin

19-May-97

Name of PRF: DO07DB **Type of BMP:** 100-Yr Detention Basin

Description: The Pinery Filing No. 22, Detention Pond B2

BMP Design: Designed only to detain 100-Yr Storm event.

Date BMP Put Into Service: **Number of Inflow Points:** 1

Watershed Area: 16.02 Acres **% of Total Watershed that is Impervious:**

Types and designs of Outlets:

10-Yr Outlet: 8.5"x8.5" Orifice; 100-Yr Outlet: 68" long weir.

Water Quality Features

Water Quality Detention Volume: 0 Ac-ft

Water Quality Detention Surface Area: 0 Acres

Water Quality Detention Basin's Length: Feet

Detention Basin's Bottom Area: 0.04 Acres

Brim full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0.36 Ac-ft **Flood Return Periods:** 10-Yr and 100-Yr

10-Yr Peak Discharge: cFs **100-Yr Peak Discharge:** cFs

Media Filter Features

Media Filter Surface Area: 300 Ft^2

Media Filter Surface: Horizontal

Number of Layers:

Depth of Each Layer:

Types of Filter Media:

Comments: Pond B1 is located just upstream of Pond B2. Pond B1 discharges to media filter located at the inlet of Pond B2.

Detention Basin

19-May-97

Name of PRF: DO08DB **Type of BMP:** Water Quality and 100-Yr Detention Basin

Description: The Pinery Filing No. 22, Detention Pond No. C1

BMP Design: Designed to detain 100-Yr Storm event.

Date BMP Put Into Service: **Number of Inflow Points:** 1

Watershed Area: 36.74 Acres **% of Total Watershed that is Impervious:**

Types and designs of Outlets:
WQ Outlet: 4" Perf Riser w/1/2" holes;10-Yr Outlet: 24"x6"; 100-Yr Outlet: 46" long weir.

Water Quality Features

Water Quality Detention Volume: 0.26 Ac-ft

Water Quality Detention Surface Area: 0.27 Acres

Water Quality Detention Basin's Length: 110 Feet

Detention Basin's Bottom Area: 0.22 Acres

Brim full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0.96 Ac-ft **Flood Return Periods:** 10-Yr and 100-Yr

10-Yr Peak Discharge: cFs **100-Yr Peak Discharge:** cFs

Media Filter Features

Media Filter Surface Area: 650 Ft^2

Media Filter Surface: Horizontal

Number of Layers:

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge= 0.152 cfs. Detention basin discharges to media filter just downstream.

Retention Basin

19-May-97

Name of PRF: DO09RP **Type of BMP:**

Description: Meridian Pond 1

BMP Design:

Date BMP put into service: **Number of Inflow Points:** 0

Watershed Area: 17 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

Permanent Pool Features

Volume of Permanent Pool: 7 Ac-ft **Permanent Pool Surface Area:** 1.8 Acres

Permanent Pool Length: 500 Feet **Littoral Zone Surface Area:** 0 Ac

Water Quality Features

Water Quality Surcharge Detention Volume: 0 Ac-ft

Water Quality Detention Surface Area: 0 Ac

Water Quality Detention Basin's Length: 0 Ft^2

Brim-full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Flood Control Features

Flood Control Volume above the Water quality Detention Volume: 0 Ac-ft

Flood Return Periods:

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2 **Media Filter Surface:**

Number of Layers: 0

Types of Filter Media:

Depth of Each Layer:

Comments: Permanent pool is stocked with white Amur (algae eating) fish and provided with aeration system.

Retention Basin

19-May-97

Name of PRF: DO10RP **Type of BMP:**

Description: Meridian Pond 2

BMP Design:

Date BMP put into service: **Number of Inflow Points:** 0

Watershed Area: 420 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

Permanent Pool Features

Volume of Permanent Pool: 13 Ac-ft **Permanent Pool Surface Area:** 3.4 Acres

Permanent Pool Length: 600 Feet **Littoral Zone Surface Area:** 0 Ac

Water Quality Features

Water Quality Surcharge Detention Volume: 0 Ac-ft

Water Quality Detention Surface Area: 0 Ac

Water Quality Detention Basin's Length: 0 Ft^2

Brim-full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Flood Control Features

Flood Control Volume above the Water quality Detention Volume: 0 Ac-ft

Flood Return Periods:

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2 **Media Filter Surface:**

Number of Layers: 0

Types of Filter Media:

Depth of Each Layer:

Comments: Permanent pool is stocked with white Amur (algae eating) fish and provided with aeration system.

Retention Basin

19-May-97

Name of PRF: DO11RP **Type of BMP:**

Description: Meridian Pond 3

BMP Design:

Date BMP put into service: **Number of Inflow Points:** 0

Watershed Area: 81 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

Permanent Pool Features

Volume of Permanent Pool: 10 Ac-ft **Permanent Pool Surface Area:** 2.8 Acres

Permanent Pool Length: 300 Feet **Littoral Zone Surface Area:** 0 Ac

Water Quality Features

Water Quality Surcharge Detention Volume: 0 Ac-ft

Water Quality Detention Surface Area: 0 Ac

Water Quality Detention Basin's Length: 0 Ft^2

Brim-full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Flood Control Features

Flood Control Volume above the Water quality Detention Volume: 0 Ac-ft

Flood Return Periods:

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2 **Media Filter Surface:**

Number of Layers: 0

Types of Filter Media:

Depth of Each Layer:

Comments: Permanent pool is stocked with white Amur (algae eating) fish and provided with aeration system.

Retention Basin

19-May-97

Name of PRF: GV01RP **Type of BMP:** Water Quality and 100-Yr Retention Basin

Description: Dayton Farms Retention Basin

BMP Design: Designed as a water quality and 100-Yr Retention Basin

Date BMP put into service: **Number of Inflow Points:** 1

Watershed Area: 77 Acres **% of Total Watershed that is Impervious:** 33.00%

Types and designs of Outlets:

WQ Outlet: 12" CMP Riser with 3/4" holes; 10-Yr Outlet: 2'11" wide x 1'9.5" high Notched Weir; 100-Yr Outlet: 10' wide Weir Box

Permanent Pool Features

Volume of Permanent Pool: 0 Ac-ft **Permanent Pool Surface Area:** 0.31 Acres

Permanent Pool Length: 0 Feet **Littoral Zone Surface Area:** 0 Ac

Water Quality Features

Water Quality Surcharge Detention Volume: 1.73 Ac-ft

Water Quality Detention Surface Area: 0.53 Ac

Water Quality Detention Basin's Length: 220 Ft^2

Brim-full Emptying Time: 12 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Flood Control Features

Flood Control Volume above the Water quality Detention Volume: 1.75 Ac-ft

Flood Return Periods: 10-Yr and 100-Yr

10-Yr Peak Discharge: 18.5 cFs **100-Yr Peak Discharge:** 77 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2 **Media Filter Surface:**

Number of Layers: 0

Types of Filter Media:

Depth of Each Layer:

Comments: WQ Discharge= 1.68 cfs.(Based on Vol/Drain Time).

Detention Basin

19-May-97

Name of PRF: GV02DB **Type of BMP:** Water Quality and 100-Yr Detention Basin

Description: Greenwood Village Municipal Maintenance Base

BMP Design: Designed as a water quality and 100-Yr detention facility.

Date BMP Put Into Service: **Number of Inflow Points:** 3

Watershed Area: 7.17 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

WQ Outlet: Perforated Riser Pipe; 10-Yr Outlet: 2- 3" Orifice Plate at different elevations; 100-Yr Outlet: 3' wide x 2'6" high Notched Weir

Water Quality Features

Water Quality Detention Volume: 0.048 Ac-ft

Water Quality Detention Surface Area: 0.075 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0.022 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0.6 Ac-ft **Flood Return Periods:** 10-Yr and 100-Yr

10-Yr Peak Discharge: 0.31 cFs **100-Yr Peak Discharge:** 1.21 cFs

Media Filter Features

Media Filter Surface Area: 100 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge=0.015 cfs (Approximated from a drain time of 40 hrs.) The WQ volume and surface area approximated from drainage plans. The media filter bed is located within the detention basin near the outlet structure.

Detention Basin

19-May-97

Name of PRF: PA01DB **Type of BMP:** Water Quality Pond Only

Description: Parker United Methodist Church (North)

BMP Design: Designed only with Water Quality Features

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 3.82 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:
WQ Outlet: 12" PVC Perforated Pipe

Water Quality Features

Water Quality Detention Volume: 0.09 Ac-ft

Water Quality Detention Surface Area: 0.1 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0.08 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge= 0.03 cfs (Assuming 40 hrs Drain Time); All parameters approximated from the field.

Detention Basin

19-May-97

Name of PRF: PA02DB **Type of BMP:** Water Quality Pond Only

Description: Parker United Methodist Church (2nd Pond from North)

BMP Design: Designed only with Water Quality Features.

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 3.82 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

WQ Outlet: 12" PVC Perforated Pipe

Water Quality Features

Water Quality Detention Volume: 0.4 Ac-ft

Water Quality Detention Surface Area: 0.28 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0.18 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Disharge= 0.12 cfs (Assuming 40 hrs Drain Time); All parameters approximated from the field.

Detention Basin

19-May-97

Name of PRF: PA03DB **Type of BMP:** Water Quality Pond Only

Description: Parker United Methodist Church (3rd Pond from North)

BMP Design: Designed only with Water Quality Features.

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 3.82 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

WQ Outlet: 12" PVC Perforated Pipe

Water Quality Features

Water Quality Detention Volume: 0.37 Ac-ft

Water Quality Detention Surface Area: 0.24 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0.14 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge= 0.11 cfs(Assuming 40 Hrs Drain Time); All parameters approximated from the field.

Detention Basin

19-May-97

Name of PRF: PA04DB **Type of BMP:** Water Quality and 100-Yr Detention Pond

Description: Parker Vista Subdivision (Stonehedge and Main Street)

BMP Design: Designed as a Water Quality and Flood Control Pond.

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 41.99 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:
WQ Outlet: Perforated Riser Pipe

Water Quality Features

Water Quality Detention Volume: 0.77 Ac-ft

Water Quality Detention Surface Area: 0.36 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0.26 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge=0.23 cfs (Based on 40 Hrs Drain Time); All parameters approximated from the field.

Detention Basin

19-May-97

Name of PRF: PA05DB **Type of BMP:** Water Quality and Detention Basin

Description: Parker Vista(North Detention Basin)

BMP Design: Designed as a Water Quality and Flood Control Facility

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 16 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

WQ Outlet: Underdrain Collection System

Water Quality Features

Water Quality Detention Volume: 0.4 Ac-ft

Water Quality Detention Surface Area: 0 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0 Acres

Brim full Emptying Time: 0 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: Currently, the existing underdrain collection system is silted up. A new water quality facility will be installed later in 1997.

Detention Basin

19-May-97

Name of PRF: PA07DB **Type of BMP:** Water Quality and Flood Control Pond

Description: Willow Ridge Filing 1

BMP Design: Designed as a Water Quality and Flood Control pond.

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 22.07 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:
WQ Outlet: Perforated Riser Pipe

Water Quality Features

Water Quality Detention Volume: 0.49 Ac-ft

Water Quality Detention Surface Area: 0.29 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0.2 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge= 0.15 cfs (Based on 40 Hrs Drain Time); All parameters approximated from the field.

Detention Basin

19-May-97

Name of PRF: PA08DB **Type of BMP:** Water Quality and Flood Control Pond

Description: Willow Ridge Filing 2

BMP Design: Designed as a Water Quality and Flood Control Pond

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 34.16 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

WQ Outlet:Perforated Riser Pipe

Water Quality Features

Water Quality Detention Volume: 1.31 Ac-ft

Water Quality Detention Surface Area: 0.55 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0.32 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptyimg Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge=0.40 cfs (Based on 40 Hrs Drain Time); All parameters approximated from the field.

Detention Basin

19-May-97

Name of PRF: PA09DB **Type of BMP:** Water Quality and Flood Control Pond

Description: Willow Park West

BMP Design: Designed as Water Quality and Flood Control Pond

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 17.71 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

WQ Outlet: Perforated Riser Pipe with Gravel Pack

Water Quality Features

Water Quality Detention Volume: 2.55 Ac-ft

Water Quality Detention Surface Area: 1.8 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 1.6 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge= 0.77 cfs (Based on 40 Hrs Drain Time); All parameters approximated from the field.

Detention Basin

19-May-97

Name of PRF: PA10DB **Type of BMP:** Water Quality and Flood Control

Description: Willow Park East

BMP Design: Designed as Water Quality and Flood Control Pond

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 21.35 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

WQ Outlet: Perforated Riser Pipe with Gravel Pack

Water Quality Features

Water Quality Detention Volume: 9.44 Ac-ft

Water Quality Detention Surface Area: 3.36 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 2.94 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge=2.86 cfs (Based on 40 Hrs Drain Time); All parameters approximated from the field.

Detention Basin

19-May-97

Name of PRF: PA11DB **Type of BMP:** Water Quality and Flood Control

Description: Parker Marketplace Phase 2 Detention Facility

BMP Design: Designed as Water Quality and Flood Control Pond

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 5.26 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

WQ Outlet: Perforated Riser Pipe

Water Quality Features

Water Quality Detention Volume: 0.21 Ac-ft

Water Quality Detention Surface Area: 0.12 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0.073 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge= 0.07 cfs (Based on 40 Hrs Drain Time); All parameters approximated from the field.

Detention Basin

19-May-97

Name of PRF: PA12DB **Type of BMP:** Water Quality and Detention Facility

Description: Bradbury Ranch

BMP Design: Designed as a water quality and detention facility.

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 374.9 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

WQ Outlet: Perforated PVC Pipe with Gravel Pack

Water Quality Features

Water Quality Detention Volume: 1.9 Ac-ft

Water Quality Detention Surface Area: 1.7 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge=1.15 cfs (Approximated based on 40 hrs drain time.) Water Quality volume and surface area approximated from USGS Quadrangle map.

Detention Basin

19-May-97

Name of PRF: PA13DB **Type of BMP:** Water Quality Facility

Description: Baldwin Pond

BMP Design: Designed as a water quality facility.

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 278.2 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

WQ Outlet: Underdrain Collection System

Water Quality Features

Water Quality Detention Volume: 0.42 Ac-ft

Water Quality Detention Surface Area: 0.43 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0 Acres

Brim full Emptying Time: 8 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge=0.635 cfs(Approximated from a 8 hour drain time.) The Water Quality Capture Volume was designed to treat the single family homes subdivision(15.58 acres). Since pond is on main stem, total contributing area is used to measure WQ benefits.

Detention Basin

19-May-97

Name of PRF: PA14DB **Type of BMP:** Water Quality and Detention Facility

Description: Joint Use Facility Detention Pond 1

BMP Design: Designed as a water quality and detention facility.

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 2.4 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

WQ Outlet: Underdrain Collection System

Water Quality Features

Water Quality Detention Volume: 0.11 Ac-ft

Water Quality Detention Surface Area: 0.093 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0.07 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge=0.034 cfs (Approximated from a 40 hour drain time.)

Detention Basin

19-May-97

Name of PRF: PA15DB **Type of BMP:** Water Quality and Detention Facility

Description: Joint Use Facility Detention Pond 2

BMP Design: Designed as a water quality and detention facility

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 4.8 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:
WQ Outlet: Underdrain Collection System

Water Quality Features

Water Quality Detention Volume: 0.435 Ac-ft

Water Quality Detention Surface Area: 0.118 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 0.06 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge= 0.132 cfs (Approximated from a 40 hour drain time.)

Detention Basin

19-May-97

Name of PRF: PA16DB **Type of BMP:** Water Quality and Detention Facility

Description: Clarke Farms Detention Pond

BMP Design: Designed as a water quality and detention facility.

Date BMP Put Into Service: **Number of Inflow Points:** 0

Watershed Area: 294 Acres **% of Total Watershed that is Impervious:** 0.00%

Types and designs of Outlets:

WQ Feature: Volume provided below principal outlet structure for retention and sedimentation of runoff.

Water Quality Features

Water Quality Detention Volume: 10.64 Ac-ft

Water Quality Detention Surface Area: 2.41 Acres

Water Quality Detention Basin's Length: 0 Feet

Detention Basin's Bottom Area: 1.85 Acres

Brim full Emptying Time: 40 Hrs **Half Brim-full Emptying Time:** 0 Hrs

Bottom Stage Volume: 0 Acres **Bottom Stage Surface Area:** 0 Acres

Forebay Volume: 0 Ac-ft **Forebay Surface Area:** 0 Acres

Vegetation Within Basin:

Flood Control Features

Flood Control Volume: 0 Ac-ft **Flood Return Periods:**

10-Yr Peak Discharge: 0 cFs **100-Yr Peak Discharge:** 0 cFs

Media Filter Features

Media Filter Surface Area: 0 Ft^2

Media Filter Surface:

Number of Layers: 0

Depth of Each Layer:

Types of Filter Media:

Comments: WQ Discharge= 3.22 cfs (Approximated from a 40 hour drain time.)

Project: Cherry Creek Basin Water Quality Authority
Nonpoint Source Evaluation
Shop Creek

Date: 4/10/97

A. Examination of Raw Data for Shop Creek Site 1 (1994-1996)

	Storm Event	Sample Type	Total Suspended Solids (mg/l)	Total Suspended Solids (lb)	Total Phosphorus (mg/l)	Total Phosphorus (lb)	Runoff Peak Discharge (cfs)	Daily Runoff Volume (cf)	Comment on Flow Data
1	6/22/94	storm	140	1302	1.034	9.62	43.50	149,013	storm peak
2	7/12/94		15	3373	0.097	21.81	300.20	3,602,400	Gage appears to be stuck at 300.2 cfs
3	7/19/94	storm	999	1016	1.161	1.18	1.81	16,294	base
4	8/9/94		146	100	0.422	0.29	0.19	10,967	0.16 cfs peak according to 10-minute data
5	9/5/94		342	224	0.372	0.24	0.17	10,505	0.15 cfs peak according to 10-minute data
1	04/04/95		28	18	0.062	0.04	0.18	10,368	base
2	04/10/95	storm	306	3119	0.434	4.42	14.29	163,296	storm peak
3	04/18/95		176	1433	0.265	2.16	11.03	130,464	storm peak @ 22:40
4	04/18/95	storm	153	1248	0.530	4.32	11.03	130,464	receding from storm
5	04/23/95	storm	389	3147	1.831	14.81	19.08	129,600	receding from storm
6	05/02/95		8	175	0.034	0.74	92.87	350,784	double peak storm @ 19:50 and 22:20
7	05/02/95		4	88	0.042	0.92	92.87	350,784	double peak storm
8	05/02/95	storm	93	2037	0.836	18.31	92.87	350,784	storm peak
9	05/16/95		17	237	0.18	2.50	83.73	222,912	storm peak
10	05/15/95	storm	674	763	1.22	1.38	1.33	18,144	storm peak
11	05/30/95		19	30	0.069	0.11	3.77	25,056	storm peak @20:10
12	05/30/95		106	166	0.122	0.19	3.77	25,056	storm peak @20:10
13	06/13/95	ud	80	142	0.191	0.34	1.04	28,512	small storm peak
14	06/13/95		103	183	0.200	0.36	1.04	28,512	
15	06/27/95		46	62	0.235	0.32	0.36	21,600	base
16	06/28/95	storm	324	8144	0.747	18.78	190.73	402,624	six peak storm
17	07/11/95		26	34	0.065	0.08	0.37	20,736	base
18	07/13/95	storm	175	642	1.000	3.67	12.63	58,752	double peak storm
19	07/25/95		4	2	0.072	0.04	0.28	8,649	base
20	08/08/95		98	69	0.144	0.10	0.29	11,232	base
21	08/21/95		17	36	0.206	0.43	18.64	33,696	storm peak
22	08/17/95	storm	182	108	0.582	0.35	0.28	9,504	storm peak
23	09/06/95		3	1	0.090	0.04	-----	7,770	estimated flow
24	09/18/95	storm	61	30	0.510	0.25	-----	7,770	estimated flow
25	09/19/95	storm	40	19	0.220	0.11	-----	7,770	estimated flow
26	09/28/95	storm	203	98	0.105	0.05	-----	7,770	estimated flow
27	10/03/95		4	-----	0.030	-----	-----	-----	o flow data
28	10/03/95	storm	59	-----	0.250	-----	-----	-----	o flow data
29	10/17/95		26	-----	0.070	-----	-----	-----	o flow data
30	10/21/95	storm	124	-----	1.040	-----	-----	-----	o flow data
31	10/31/95		3	-----	0.040	-----	-----	-----	o flow data
1	04/02/96		9	-----	0.025	-----	-----	-----	o flow data
2	04/16/96		3	-----	0.108	-----	-----	-----	o flow data
3	04/30/96		6	-----	0.014	-----	-----	-----	o flow data
4	05/09/96	storm	13	-----	0.124	-----	-----	-----	o flow data
5	05/14/96		8	-----	0.125	-----	-----	-----	o flow data
6	05/25/96	assume storm	150	4319	0.460	13.24	29.11	461,173	storm started on 24th and ended on 26th
7	05/28/96		1	4	0.056	0.23	10.45	86,006	
8	06/11/96		84	215	0.108	0.28	0.71	41,001	
9	06/15/96	assume storm	501	15585	0.712	22.15	78.28	498,282	storm started at 11am and ended at 6 pm
10	06/20/96		221	723	0.606	1.98	7.10	52,423	
11	06/25/96		26	64	0.085	0.21	0.46	39,577	
12	07/09/96		4	103	0.082	2.10	83.00	410,552	
13	07/09/96	storm	4	103	0.193	4.95	83.00	410,552	
14	07/23/96		3	11	0.081	0.28	0.98	56,260	
15	08/06/96		5	19	0.077	0.29	1.06	59,992	
16	08/07/96	storm	-----	-----	0.829	5.96	11.27	115,104	
17	08/20/96		5	12	0.061	0.15	0.46	39,577	
18	08/23/96	assume storm	438	2021	0.815	3.76	13.17	73,894	storm on 23rd did not start until 10 pm
19	09/03/96		18	44	0.060	0.15	0.46	39,577	
20	09/06/96	storm	128	654	0.452	2.31	13.17	81,798	
21	09/12/96	assume storm	521	3716	0.111	0.79	15.53	114,257	a storm occurred the previous evening
22	09/17/96		3	29	0.355	3.38	25.98	152,581	
23	10/01/96		7	21	0.063	0.19	0.66	47,333	
24	10/15/96		16	51	0.085	0.27	0.90	50,802	
25	10/29/96		5	15	0.023	0.07	0.60	48,427	

Note: Storm events samples were collected in the morning. According to Chadwick the actual storm event usually occurred the day before the sample collection date shown in the raw data. Therefore, the dates shown in the table above for sampled storm events were adjusted to the previous date to match the actual date of the storm event. The only exception is the 9/6/96 storm sample. In this case, the flow data indicates that a storm occurred on 9/6/96, but no storm occurred on the previous day, 9/5/96. Therefore, it was assumed that the 9/6/96 sample reflects the storm that occurred on 9/6/96.

The 5/25/96, 6/15/96, 8/23/96, and 9/12/96 grab samples were "base" samples according to the raw data. However, the high TSS and TP values along with available flow data from Shop Creek, indicates that the grab samples may have been taken during storm events. It is assumed for this analysis that these particular grab samples represent "storm" samples.

B. Raw Storm Flow Data for Shop Creek Site 1(1995)

	Storm Event	Sample Type	Total Suspended Solids (mg/l)	Total Suspended Solids (lb)	Total Phosphorus (mg/l)	Total Phosphorus (lb)	Runoff Peak Discharge (cfs)	Daily Runoff Volume (cf)
1	04/10/95	storm	306	3,119	0.434	4.42	14.29	163,296
2	04/18/95	storm	153	1,246	0.530	4.32	11.03	130,464
3	04/23/95	storm	389	3,147	1.831	14.81	19.08	129,600
4	05/02/95	storm	93	2,037	0.836	18.31	92.87	350,784
5	05/15/95	storm	674	763	1.220	1.38	1.33	18,144
6	06/28/95	storm	324	8,144	0.747	18.78	190.73	402,624
7	07/13/95	storm	175	642	1.000	3.67	12.63	58,752
8	08/17/95	storm	182	108	0.582	0.35	0.28	9,504
9	09/18/95	storm	61	30	0.510	0.25	---	7,770
10	09/19/95	storm	40	19	0.220	0.11	---	7,770
11	09/28/95	storm	203	98	0.105	0.05	---	7,770
12	10/03/95	storm	59	---	0.250	-----	-----	-----
13	10/21/95	storm	124	-----	1.040	-----	-----	-----
		Totals	2783	19,354	9.305	66.44	342.24	1,286,478
	Averages (Flow Weighted)		241		0.827		42.78	116,953
	Averages (Mathematical)		214	1759	0.716	6.04	42.78	116,953
	Averages (UDFCD)		206		0.679			

Note: Disregarded 1994 data because of questionable flow data results.

C. Raw Base Flow Data for Shop Creek Site 1 (1995)

	Storm Event	Sample Type	Total Suspended Solids (mg/l)	Total Suspended Solids (lb)	Total Phosphorus (mg/l)	Total Phosphorus (lb)	Runoff Peak Discharge (cfs)	Daily Runoff Volume (cf)
1	04/04/95		28	18	0.062	0.04	0.18	10,368
2	04/18/95		176	1,433	0.265	2.16	11.03	130,464
3	05/02/95		8	175	0.034	0.74	92.87	350,784
4	05/02/95		4	88	0.042	0.92	92.87	350,784
5	05/16/95		17	237	0.180	2.50	83.73	222,912
6	05/30/95		19	30	0.069	0.11	3.77	25,056
7	05/30/95		106	166	0.122	0.19	3.77	25,056
8	06/13/95	ud	80	142	0.191	0.34	1.04	28,512
9	06/13/95		103	183	0.200	0.36	1.04	28,512
10	06/27/95		46	62	0.235	0.32	0.36	21,600
11	07/11/95		26	34	0.065	0.08	0.37	20,736
12	07/25/95		4	2	0.072	0.04	0.28	8,649
13	08/08/95		98	69	0.144	0.10	0.29	11,232
14	08/21/95		17	36	0.206	0.43	18.64	33,696
15	09/06/95		3	1	0.090	0.04	---	7,770
16	10/03/95		4	---	0.030	-----	-----	---
17	10/17/95		26	-----	0.070	---	-----	-----
18	10/31/95		3	---	0.040	-----	---	-----
		Totals	768	2,676	2.117	8.38	310.24	1,276,131
	Averages (Flow Weighted)		33.6		0.105			85,075
	Averages (Mathematical)		42.7	178	0.118	0.56	22.16	85,075
	Averages (UDFCD)		33.9		0.111			

Note: Disregarded 1994 data because of questionable flow data results.

D. Raw Storm Flow Data for Shop Creek Site 1 (1996)

	Storm Event	Sample Type	Total Suspended Solids (mg/l)	Total Suspended Solids (lb)	Total Phosphorus (mg/l)	Total Phosphorus (lb)	Runoff Peak Discharge (cfs)	Daily Runoff Volume (cf)
1	05/09/96	storm	13	---	0.124	---	-----	-----
2	05/25/96	assume storm	150	4,319	0.460	13.24	29.11	461,173
3	06/15/96	assume storm	501	15,585	0.712	22.15	78.28	498,262
4	07/09/96	storm	4	103	0.193	4.95	63.00	410,552
5	08/07/96	storm	-----	-----	0.829	5.96	11.27	115,104
6	08/23/96	assume storm	438	2,021	0.815	3.76	13.17	73,894
7	09/06/96	storm	128	654	0.452	2.31	13.17	81,798
8	09/12/96	assume storm	521	3,716	0.111	0.79	15.53	114,257
		Totals	1,755	26,396	3.696	53.16	243.53	1,755,060
	Averages (Flow Weighted)		258		0.485			250,723
	Averages (Mathematical)		251	4399	0.462	7.59	34.79	250,723

Note: No TSS data available for 8/7/96 storm event.

E. Raw Base Flow Data for Shop Creek Site 1 (1996)

	Storm Event	Sample Type	Total Suspended Solids (mg/l)	Total Suspended Solids (lb)	Total Phosphorus (mg/l)	Total Phosphorus (lb)	Runoff Peak Discharge (cfs)	Daily Runoff Volume (cf)
1	04/02/96		9	----	0.025	----	----	----
2	04/16/96		3	----	0.106	----	----	----
3	04/30/96		6	----	0.014	----	----	----
4	05/14/96		8	----	0.125	----	----	----
5	05/28/96		1	4	0.056	0.23	10.45	66,006
6	06/11/96		84	215	0.108	0.28	0.71	41,001
7	06/20/96		221	723	0.606	1.98	7.10	52,423
8	06/25/96		28	64	0.085	0.21	0.46	39,577
9	07/09/96		4	103	0.082	2.10	83.00	410,552
10	07/23/96		3	11	0.081	0.28	0.98	56,260
11	08/06/96		5	19	0.077	0.29	1.06	59,992
12	08/20/96		5	12	0.061	0.15	0.46	39,577
13	09/03/96		18	44	0.060	0.15	0.46	39,577
14	09/17/96		3	29	0.355	3.38	25.98	152,581
15	10/01/96		7	21	0.063	0.19	0.66	47,333
16	10/15/96		16	51	0.085	0.27	0.90	50,802
17	10/29/96		5	15	0.023	0.07	0.60	48,427
		Totals	424	1,310	2.012	9.58	132.82	1,104,108
	Averages (Flow Weighted)		19		0.139			84,931
	Averages (Mathematical)		25	101	0.118	0.74	10.22	84,931

F. Average EMC, Base Flow, Storm Runoff for 1990, 1991, 1992, and 1995 at Shop Creek Site Site 1

Average base flow rate data was obtained from Rich Ommert/UDFCD on 1-24-97 over the telephone.

Year	Base Flow Sample Period	Storm Flow Sample Period	Average Base Flow Rate (cfs)	Total # of Storm Events	Storm Runoff Volume (cf*1000)
1990	Apr 3 - Oct 1	Apr 18 - Oct 2	0.665	22	7191
1991	Apr 10 - Oct 1	Apr 10 - Nov 1	0.406	44	5978
1992	Mar 31 - Sep 23	May 9 - Aug 25	0.357	41	4357
1995	Apr 1 - Aug 8	Apr 9 - Oct 22	0.671	48	6365

E. Total Monthly Storm Flows for Shop Creek Site 1 (Measured)

Month	Storm Runoff Volumes (cf) 1990	1991	1992	1995	1996	Total	Ave Annual	Days in Month	Storm Days 1990	1991	1992	1995
Jan	-----	----	-----	----	----	0		31	----	----	-----	-----
Feb	----	----	----	----	-----	0		28	----	-----	-----	----
Mar	-----	-----	-----	----	-----	0		31	----	-----	-----	----
Apr	1,402,000	581,100	0	1,120,500	-----	3,103,600		30	2	7	0	11
May	823,000	786,000	313,400	2,385,300	1,486,848	5,794,548		31	2	7	9	11
Jun	156,000	720,100	846,400	1,308,700	921,927	3,953,127		30	1	12	9	10
Jul	2,131,000	1,319,900	1,664,300	464,600	811,408	6,391,208		31	10	8	13	4
Aug	1,646,000	1,624,000	1,533,300	371,500	463,888	5,638,688		31	3	5	10	5
Sep	1,033,000	632,300	0	528,200	2,146,823	4,340,323		30	3	1	0	5
Oct	-----	314,100	----	185,500	227,206	726,806		31	1	4	----	2
Nov	-----	----	----	-----	143,468	143,468		30	----	----	-----	----
Dec	-----	-----	-----	-----	-----	0		31	----	----	----	-----
Total Yearly Flows (cf) =	7,191,000	5,977,500	4,357,400	6,364,300	6,201,568	30,091,768	6,018,354		22	44	41	48
Total Yearly Flows (af) =	165	137	100	146	142	691	138					
Ave Total Phosphorus (mg/l) =	0.533	0.356	0.448	0.879	0.462	-----	0.502					
Total Phosphorus (lb) =	239	133	122	270	179	764	153					
Ave Total Suspended Solids (mg/l) =	195	102	104	206	251	-----	126					
Total Suspended Solids (lb) =	87,541	38,063	28,291	81,847	97,066	235,742	47,148					
Total Suspended Solids (tons) =	44	19	14	41	49	118	24					

Note: Included Oct. 2, 1994 storm in total for month of Sept., because there were only 2 days of data in Oct.
Included Nov. 1, 1995 storm in total for month of Oct., because there was only 1 day of data in Nov.
Storm flow volumes for 1990-1992 and 1995 were taken directly from the "Internal UDFCD Report on the Joint Shop Creek Pond-Wetland System Performance" updated in 12/96. Storm flow volumes for 1996 were based on measured gage data. Storm flow volume for May 1996 was based only on measured data for the last portion of the month from May 23 to May 31, 1996.

F. Total Monthly Base Flows for Shop Creek Site 1 (Measured)

Month	Base Flow Runoff Volumes (cf) 1990	1991	1992	1995	1996	Total	Ave Annual	Days in Month	Base Flow Days 1990	1991	1992	1995
Jan	-----	----	-----	----	----	0		31	-----	-----	-----	-----
Feb	-----	----	----	-----	----	0		28	----	----	----	-----
Mar	----	-----	-----	----	----	0		31	----	----	-----	----
Apr	1,608,768	806,803	925,344	1,101,514	----	4,442,429		30	28	23	30	19
May	1,666,224	841,882	678,586	1,159,488	1,145,103	5,491,282		31	29	24	22	20
Jun	1,666,224	631,411	647,741	1,159,488	949,874	5,054,738		30	29	18	21	20
Jul	1,206,576	806,803	555,206	1,565,309	1,177,860	5,311,754		31	21	23	18	27
Aug	1,608,768	912,038	647,741	1,507,334	1,143,703	5,819,585		31	28	26	21	26
Sep	1,551,312	1,017,274	925,344	1,449,360	963,512	5,906,802		30	27	29	30	25
Oct	----	947,117	-----	1,681,258	1,427,361	4,055,735		31	30	27	-----	29
Nov	-----	----	-----	-----	1,369,259	1,369,259		30	-----	----	-----	-----
Dec	----	-----	----	----	1,560,872	1,560,872		31	----	----	----	-----
Total Yearly Flows (cf) =	9,307,872	5,963,328	4,379,962	9,623,750	9,737,544	39,012,456	7,802,491		192	170	142	166
Total Yearly Flows (af) =	214	137	101	221	224	896	179					
Ave Total Phosphorus (mg/l) =	0.096	0.156	0.074	0.111	0.118	-----	0.112					
Total Phosphorus (lb) =	56	58	20	67	72	201	40					
Ave Total Suspended Solids (mg/l) =	9.0	10.0	1.0	33.9	25	----	18					
Total Suspended Solids (lb) =	5,230	3,723	273	20,367	15,162	29,593	5,919					
Total Suspended Solids (tons) =	3	2	0	10	8	15	3					

Note: For 1990-1995, TP and TSS concentrations (mg/l) were taken directly from the "Internal UDFCD Report on the Joint Shop Creek Pond-Wetland System Performance" updated in 12/96. Base flow volumes for 1990-1995 were computed based on average base flow rates estimated by UDFCD (see section D). For May 1996, flow data was only available for the last part of the month from May 23 to May 31. For Dec 1996, flow data was only available from Dec 1 through Dec 5. Base flow runoff volume for the months of May and Dec were estimated based on the average base flow for the measured days times the total number of days in the month.

G. Total Monthly Storm and Base Flows for Shop Creek Site 1 (Measured)

	Total Runoff Volumes (cf)						
Month	1990	1991	1992	1995	1996	Total	Ave Annual
Jan	----	----	----	----	----	0	
Feb	----	----	----	----	----	0	
Mar	----	----	----	----	----	0	
Apr	3,010,768	1,387,903	925,344	2,222,014	----	7,546,029	
May	2,489,224	1,627,882	991,988	3,544,788	2,831,951	8,653,879	
Jun	1,822,224	1,351,511	1,494,141	2,468,188	1,871,801	7,136,064	
Jul	3,337,576	2,126,703	2,219,506	2,029,909	1,989,268	9,713,694	
Aug	3,254,768	2,536,038	2,181,041	1,878,834	1,607,591	9,850,682	
Sep	2,584,312	1,649,574	925,344	1,977,560	3,110,335	7,136,790	
Oct	----	1,281,217	----	1,866,758	1,654,567	3,127,974	
Nov	----	----	----	----	1,512,727	0	
Dec	----	----	----	----	----	0	
Total Yearly Flows (cf) =	16,498,872	11,940,828	8,737,362	15,988,050	14,378,240	53,165,112	10,633,022
Total Yearly Flows (af) =	379	274	201	367	330	1,221	244
Ave Total Phosphorus (mg/l) =	0.286	0.256	0.261	0.337	0.279	----	0.386
Total Phosphorus (lb) =	295	191	142	336	251	1,215	243
Ave Total Suspended Solids (mg/l) =	90	56	52	102	125	----	114
Total Suspended Solids (lb) =	92,770	41,786	28,564	102,214	112,228	377,563	75,513
Total Suspended Solids (tons) =	46	21	14	51	56	189	38
% TSS Removal =							

H. Total Monthly Storm Flows for Shop Creek Site 1 (Estimated)

	Storm Runoff Volumes (cf)							Denver Average Monthly Rainfall		
Month	1990	1991	1992	1995	1996	Total	Ave Annual	(ft)	(in)	(% of total)
Jan	293,277	223,830	177,712	236,314	152,047	1,085,180		0.0360	0.43	2.8%
Feb	354,377	270,461	214,736	287,962	183,723	1,311,259		0.0435	0.52	3.4%
Mar	865,983	660,920	524,744	703,687	448,960	3,204,294		0.1063	1.28	8.4%
Apr	1,402,000	581,100	0	1,120,500	560,038	3,663,638		0.1326	1.59	10.5%
May	823,000	786,000	313,400	2,385,300	1,486,848	5,794,548		0.2494	2.99	19.7%
Jun	156,000	720,100	846,400	1,308,700	921,927	3,953,127		0.1495	1.79	11.8%
Jul	2,131,000	1,319,900	1,664,300	464,600	811,408	6,391,208		0.1228	1.47	9.7%
Aug	1,646,000	1,624,000	1,533,300	371,500	463,888	5,638,688		0.1190	1.43	9.4%
Sep	1,033,000	632,300	0	528,200	2,146,823	4,340,323		0.1094	1.31	8.6%
Oct	641,137	314,100	388,458	185,500	227,206	1,756,441		0.0787	0.94	6.2%
Nov	572,706	437,090	347,032	465,374	143,468	1,965,669		0.0703	0.84	5.6%
Dec	385,334	294,088	233,494	313,116	199,772	1,425,805		0.0473	0.57	3.7%
Total Yearly Flows (cf) =	10,303,814	7,863,888	6,243,616	8,372,755	7,746,107	40,530,180	8,106,036	1.2648	15.18	100%
Total Yearly Flows (af) =	237	181	143	192	178	930	186			
Ave Total Phosphorus (mg/l) =	0.533	0.358	0.448	0.679	0.462	----	0.502			
Total Phosphorus (lb) =	343	175	175	355	223	1,271	254			
Ave Total Suspended Solids (mg/l) =	195	102	104	206	251	----	176			
Total Suspended Solids (lb) =	125,435	50,075	40,537	107,677	121,241	444,965	88,993			
Total Suspended Solids (tons) =	63	25	20	54	61	222	44			

Note: Total runoff volumes shown with shaded background were estimated by linear interpolation using the average monthly rainfall data for Denver.

I. Total Monthly Base Flows for Shop Creek Site 1 (Estimated)

Assumed % of winter (unmeasured) base flows to summer (measured) base flows = 67% (value calibrated to average Denver precipitation)

Month	Base Flow Runoff Volumes (cf) 1990	1991	1992	1995	1996	Total	Ave Annual
Jan	1,039,379	570,776	489,096	921,130	815,519	3,835,900	
Feb	1,039,379	570,776	489,096	921,130	815,519	3,835,900	
Mar	1,039,379	570,776	489,096	921,130	815,519	3,835,900	
Apr	1,608,768	806,803	925,344	1,101,514	815,519	5,257,948	
May	1,666,224	841,882	678,586	1,159,488	1,145,103	5,491,282	
Jun	1,666,224	831,411	647,741	1,159,488	949,874	5,054,738	
Jul	1,206,576	806,803	555,206	1,565,309	1,177,860	5,311,754	
Aug	1,608,768	912,038	647,741	1,507,334	1,143,703	5,819,585	
Sep	1,551,312	1,017,274	925,344	1,449,360	963,512	5,906,802	
Oct	1,039,379	947,117	489,096	1,681,258	1,427,361	5,584,210	
Nov	1,039,379	570,776	489,096	921,130	1,369,259	4,389,640	
Dec	1,039,379	570,776	489,096	921,130	1,560,872	4,581,253	
Total Yearly Flows (cf) =	15,544,146	8,817,206	7,314,536	14,229,402	12,999,621	58,904,912	11,780,982
Total Yearly Flows (af) =	357	202	168	327	298	1,352	270
Ave Total Phosphorus (mg/l) =	0.096	0.156	0.074	0.111	0.118	---	0.111
Total Phosphorus (lb) =	93	86	34	99	96	407	81
Ave Total Suspended Solids (mg/l) =	9.0	10.0	1.0	33.9	25	-----	18
Total Suspended Solids (lb) =	8,734	5,504	457	30,114	20,241	65,050	13,010
Total Suspended Solids (tons) =	4	3	0	15	10	33	7

Note: Base flow volumes for the unmeasured months (winter) were estimated assuming 67% of the average monthly base flow for the measured months (summer).

J. Total Monthly Storm and Base Flows for Shop Creek Site 1 (Estimated)

Month	Total Runoff Volumes (cf) 1990	1991	1992	1995	1996	Total	Ave Annual
Jan	1,332,656	794,606	666,808	1,159,444	967,566	4,921,080	
Feb	1,393,758	841,237	703,831	1,209,093	999,242	5,147,159	
Mar	1,905,362	1,231,695	1,013,840	1,624,818	1,264,479	7,040,194	
Apr	3,010,768	1,387,903	925,344	2,222,014	1,375,557	8,921,586	
May	2,489,224	1,627,882	991,986	3,544,788	2,631,951	11,285,830	
Jun	1,822,224	1,351,511	1,494,141	2,466,188	1,871,801	9,007,865	
Jul	3,337,576	2,126,703	2,219,506	2,029,909	1,989,268	11,702,962	
Aug	3,254,768	2,536,038	2,181,041	1,878,834	1,607,591	11,458,273	
Sep	2,584,312	1,849,574	925,344	1,977,580	3,110,335	10,247,125	
Oct	1,680,516	1,281,217	877,594	1,866,758	1,654,567	7,340,651	
Nov	1,612,085	1,007,866	836,128	1,386,504	1,512,727	6,355,309	
Dec	1,424,713	864,883	722,590	1,234,248	1,760,644	6,007,058	
Total Yearly Flows (cf) =	25,847,960	16,681,094	13,558,152	22,602,157	20,745,729	99,435,092	19,887,018
Total Yearly Flows (af) =	593	383	311	519	476	2,283	457
Ave Total Phosphorus (mg/l) =	0.270	0.250	0.246	0.321	0.247		0.270
Total Phosphorus (lb) =	436	261	208	454	319	1,678	336
Ave Total Suspended Solids (mg/l) =	83	53	48	98	109		82
Total Suspended Solids (lb) =	134,169	55,580	40,994	137,791	141,482	510,015	102,003
Total Suspended Solids (tons) =	67	28	20	69	71	255	51

K. Summary of Measured Inflow Loads (Shop Creek Site 1)

Monitoring period generally April through September or October for the years 1990, 1991, 1992, 1995, and 1996.

Event Type	Runoff Volume (AF)	Percent of Total Runoff Volume	TSS (mg/l)	TSS (tons)	Percent of Total TSS	TP (mg/l)	TP (lbs)	Percent of Total TP
Base flow	896	56%	18	22	16%	0.112	273	22%
Storm flow	691	44%	126	118	84%	0.502	943	78%
Total	1586			140			1215	

L. Estimated Average Annual Inflow Loads (Shop Creek Site 1)

Event Type	Runoff Volume (af/yr)	Percent of Total Runoff Volume	TSS (mg/l)	TSS (tons/yr)	Percent of Total TSS	TP (mg/l)	TP (lb/yr)	Percent of Total TP
Base flow	270	59%	18	7	13%	0.111	81	24%
Storm flow	186	41%	176	44	87%	0.502	254	76%
Total	457			51			336	

M. Unit Loading Rates (Shop Creek Site 1)

Drainage Area = 390 ac Mixed urban land use

Average annual precip = 15.18 in

Event Type	Runoff Volume (af/ac)	Percent Runoff	TSS (tons/ac)	TP (lb/ac)
Base flow	0.69	55%	0.02	0.21
Storm flow	0.48	38%	0.11	0.65
Total	1.17	93%	0.13	0.86

N. Estimated Removal Efficiencies of Shop Creek Joint Pond-Wetland System

	1990-1992	1995	1996	Total	Average
otal Phosphorus					
Measured Total Inflow Load (lb)	628	336	251	1,215	
% Total Load Removed	44.0%	69.8%	59.7%		54%
Measured Total Load Removed (lb)	276	235	150	661	
Measured Storm Inflow Load (lb)	494	270	179	943	
% Storm Load Removed	51.0%	82.1%	72.5%		64%
Measured Storm Load Removed (lb)	252	221	130	603	
Measured Base Inflow Load (lb)	134	67	72	273	
% Base Load Removed	18.2%	20.0%	28.0%		21%
Measured Base Load Removed (lb)	24	13	20	58	
Total Suspended Solids					
Measured Total Inflow Load (lb)	163,121	102,214	112,228	377,563	
% Total Load Removed	68.0%	91.3%	94.2%		82%
Measured Total Load Removed (lb)	110,922	93,322	105,686	309,930	
Measured Storm Inflow Load (lb)	153,895	81,847	97,066	332,808	
% Storm Load Removed	72.0%	92.6%	97.9%		85%
Measured Storm Load Removed (lb)	110,804	75,791	95,027	281,622	
Measured Base Inflow Load (lb)	9,226	20,367	15,162	44,755	
% Base Load Removed	1.3%	86.1%	70.3%		63%
Measured Base Load Removed (lb)	118	17,531	10,659	28,308	

Note: For 1990-1992 and 1995, percent removal rates for "total loads" and "storm loads" were taken directly from the "Internal UDFCD Report on the Joint Shop Creek Pond-Wetland System Performance" updated in 12/96. For 1990-1992 and 1995, percent removal rates for "base flow loads" were computed by subtracting "storm loads" from "total loads." For 1996, percent removal rates were estimated from raw data collected by Chadwick.

O. Average Annual Loads Removed by System

Event Type	Estimated TSS Removal Efficiency	TSS In (tons/yr)	TSS Removed (tons/yr)	TSS Out (tons/yr)	Estimated TP Removal Efficiency	TP In (lb/yr)	TP Removed (lb/yr)	TP Out (lb/yr)
Base flow	63%	7	4	2	21%	81	17	64
Storm flow	85%	44	38	7	64%	254	163	92
Total	82%	51	42	9	54%	336	180	156

B. Raw Storm Flows Only

Inflow to Water Quality Pond (Site 1)

	Storm Event	Sample Type	Total Suspended Solids (mg/l)	Total Suspended Solids (lb)	Total Phosphorus (mg/l)	Total Phosphorus (lb)	Runoff Peak Discharge (cfs)	Daily Runoff Volume (cf)
1	05/10/96	storm	6	2	0.170	0.1	6.09	5,501
2	05/25/96	assume storm	100	1848	0.295	5.5	10.42	295,988
3	05/28/96	assume storm	3	11	0.107	0.4	4.92	58,396
4	07/09/96	storm	208	1274	0.514	3.1	10.85	98,116
5	08/08/96	storm	298	203	0.770	0.5	0.66	10,897
6	08/23/96	assume storm	208	750	0.286	1.0	4.14	57,730
7	09/05/96	storm	162	309	0.338	0.6	7.12	30,518
8	09/06/96	assume storm	86	246	0.162	0.5	4.47	45,900
9	09/12/96	assume storm	140	961	0.075	0.5	7.49	110,002
		Totals	1211	5604	2.717	12.2	56.16	713,048
	Averages (Mathematical)		135	623	0.302	1.4	6.24	79,228

Outflow from Water Quality Pond (Site 2)

	Storm Event	Sample Type	Total Suspended Solids (mg/l)	Total Suspended Solids (lb)	Total Phosphorus (mg/l)	Total Phosphorus (lb)	Runoff Peak Discharge (cfs)	Runoff Volume (cf)
1	05/10/96	storm	18	—	0.287	—	—	----
2	05/25/96	assume storm	14	0	0.230	0.0	0.00	0
3	05/28/96	assume storm	10	0	0.244	0.0	0.00	0
4	06/15/96	assume storm	258	1104	0.568	2.4	2.60	68,568
5	06/21/96	assume storm	43	44	0.288	0.3	1.53	16,509
6	07/09/96	storm	45	23	0.306	0.2	2.11	8,280
7	08/23/96	assume storm	52	31	0.532	0.3	1.45	9,447
8	09/12/96	assume storm	28	75	0.106	0.3	2.33	
		Totals	468	1278	2.561	3.5	10.02	102,804
	Averages (Mathematical)		59	183	0.320	0.5	1.43	17,134

C. Raw Base Flows Only

Inflow to Water Quality Pond (Site 1)

	Storm Event	Sample Type	Total Suspended Solids (mg/l)	Total Suspended Solids (lb)	Total Phosphorus (mg/l)	Total Phosphorus (lb)	Runoff Peak Discharge (cfs)	Daily Runoff Volume (cf)
1	04/02/96		4	---	0.006	---	---	---
2	04/16/96		3	---	0.043	---	---	---
3	04/30/96		5	---	0.009	---	---	---
4	05/14/96		13	2	0.122	0.0	0.3	2,332
5	06/11/96		4	7	0.196	0.3	0.8	26,861
6	06/16/96		4	13	0.218	0.7	2.4	52,915
7	06/20/96		3	3	0.29	0.3	1.5	15,914
8	06/25/96		3	3	0.192	0.2	0.7	18,530
9	07/09/96		7	43	0.225	1.4	10.9	98,116
10	07/23/96		2	2	0.199	0.2	0.7	16,027
11	08/06/96		5	4	0.147	0.1	0.6	12,854
12	08/20/96		7	8	0.151	0.2	0.7	19,064
13	09/03/96		5	5	0.13	0.1	0.7	15,971
14	09/17/96		4	25	0.11	0.7	8.9	98,307
15	10/01/96		3	7	0.164	0.4	0.7	37,887
16	10/15/96		3	9	0.124	0.4	1.0	49,856
17	10/29/96		4	10	0.037	0.1	0.6	39,802
		Totals	79	141	2.363	5.1	30.46	504,436
	Averages (Mathematical)		5	10	0.139	0.4	2.18	36,031

Outflow from Water Quality Pond (Site 2)

	Storm Event	Sample Type	Total Suspended Solids (mg/l)	Total Suspended Solids (lb)	Total Phosphorus (mg/l)	Total Phosphorus (lb)	Runoff Peak Discharge (cfs)	Daily Runoff Volume (cf)
		Totals	0	0	0.000	0.0	0.00	0
	Averages (Mathematical)		0	0	0.000	0.0	0.00	0

Note: Based on 1996 data, it is assumed that there is no "base" outlfow.

D. Total Monthly Storm Flows (Measured)

Month	Runoff Volumes (cf) 1996 (inflow)	1996 (outflow)
Jan	-----	----
Feb	-----	----
Mar	-----	----
Apr	-----	----
May	934,546	0
Jun	397,814	101,577
Jul	263,187	56,816
Aug	273,570	32,649
Sep	1,090,290	274,944
Oct	203,690	4,798
Nov	232,227	0
Dec	-----	0
Total Yearly Flows (cf) =	3,375,324	470,784
Total Yearly Flows (af) =	77	11
Ave Total Phosphorus (mg/l) =	0.302	0.320
Total Phosphorus (lb) =	64	9
Ave Total Suspended Solids (mg/l) =	135	59
Total Suspended Solids (lb) =	28,353	1,719
Total Suspended Solids (tons) =	14	1

Note: Only partial flow data for months with light shaded background. Total runoff volumes for these months were estimated by interpolation of the partial flow data available.

E. Total Monthly Base Flows (Measured)

Month	Runoff Volumes (cf) 1996 (inflow)	1996 (outflow)
Jan	-----	----
Feb	-----	----
Mar	-----	----
Apr	-----	----
May	504,096	0
Jun	610,334	0
Jul	435,893	0
Aug	431,981	0
Sep	630,328	0
Oct	1,389,576	0
Nov	1,354,920	0
Dec	----	0
Total Yearly Flows (cf) =	5,357,128	0
Total Yearly Flows (af) =	123	0
Ave Total Phosphorus (mg/l) =	0.139	0.000
Total Phosphorus (lb) =	46	0
Ave Total Suspended Solids (mg/l) =	5	0
Total Suspended Solids (lb) =	1,554	0
Total Suspended Solids (tons) =	1	0

Note: Only partial flow data for months with light shaded background. Total runoff volumes for these months were estimated by interpolation of the partial flow data available.

F. Total Monthly Storm and Base Flows (Measured)

Month	Runoff Volumes (cf) 1996 (inflow)	1996 (outflow)
Jan	----	----
Feb	----	----
Mar	----	----
Apr	----	----
May	1,438,642	0
Jun	1,008,148	101,577
Jul	699,080	56,816
Aug	705,551	32,649
Sep	1,720,618	274,944
Oct	1,593,266	4,798
Nov	1,567,147	0
Dec	----	0
Total Yearly Flows (cf) =	8,732,452	470,784
Total Yearly Flows (af) =	200	11
Ave Total Phosphorus (mg/l) =	0.202	0.320
Total Phosphorus (lb) =	110	9
Ave Total Suspended Solids (mg/l) =	55	59
Total Suspended Solids (lb) =	29,907	1,719
Total Suspended Solids (tons) =	15	1

G. Total Monthly Storm Flows (Estimated)

Month	Runoff Volumes (cf) 1996 (inflow)	1996 (outflow)	Denver Average Monthly Rainfall (ft)	(in)	(% of total)
Jan	135,148	17,900	0.0360	0.43	2.8%
Feb	163,404	21,639	0.0435	0.52	3.4%
Mar	399,065	52,879	0.1063	1.28	8.4%
Apr	497,765	65,931	0.1326	1.59	10.5%
May	934,546	0	0.2494	2.99	19.7%
Jun	397,814	101,577	0.1495	1.79	11.8%
Jul	263,187	56,816	0.1228	1.47	9.7%
Aug	273,570	32,649	0.1190	1.43	9.4%
Sep	1,090,290	274,944	0.1094	1.31	8.6%
Oct	203,690	4,798	0.0787	0.94	6.2%
Nov	212,227	0	0.0703	0.84	5.6%
Dec	137,570	0	0.0473	0.57	3.7%
Total Yearly Flows (cf) =	4,748,204	629,171	1.2648	15.18	100%
Total Yearly Flows (af) =	109	14			
Ave Total Phosphorus (mg/l) =	0.302	0.320			
Total Phosphorus (lb) =	89	13			
Ave Total Suspended Solids (mg/l) =	135	59			
Total Suspended Solids (lb) =	39,886	2,298			
Total Suspended Solids (tons) =	20	1			
Estimated TP Removal Efficiency =	86%				
Estimated TSS Removal Efficiency =	94%				

Note: Total runoff volumes shown with shaded background were estimated by linear interpolation using the average monthly rainfall data for Denver.

H. Total Monthly Base Flows (Estimated)

Assumed % of winter (unmeasured) base flows to summer (measured) base flows = 67% (value calibrated to average Denver precipitation)

Month	Runoff Volumes (cf) 1996 (inflow)	1996 (outflow)
Jan	[redacted]	[redacted]
Feb	[redacted]	[redacted]
Mar	[redacted]	[redacted]
Apr	[redacted]	[redacted]
May	504,096	0
Jun	610,334	0
Jul	435,893	0
Aug	431,981	0
Sep	630,328	0
Oct	1,389,576	0
Nov	1,354,920	0
[illegible]	[redacted]	0
Total Yearly Flows (c[illegible] =	7,920,896	0
Total Yearly Flows (af) =	182	0
Ave Total Phosphorus (mg/l) =	0.139	0.000
Total Phosphorus (lb) =	69	0
Ave Total Suspended Solids (mg/l) =	5	0
Total Suspended Solids (lb) =	2,298	0
Total Suspended Solids (tons) =	1	0
Estimated TP Removal Efficiency =	100%	
Estimated TSS Removal Efficiency =	100%	

Note: Base inflow volumes for the unmeasured months (winter) were estimated assuming 67% of the average monthly base inflow for the measured months (summer).

Note: Data for May thru Dec indicates a base outflow of 0.0 cfs, therefore, it was assumed that the base outflow for Jan thru Apr was also 0.0 cfs

I. Total Monthly Storm and Base Flows (Estimated)

Month	Runoff Volumes (cf) 1996 (inflow)	1996 (outflow)
Jan	647,902	17,908
Feb	676,058	21,639
Mar	911,816	52,879
Apr	1,010,549	65,961
May	1,438,642	0
Jun	1,008,148	101,577
Jul	699,080	56,816
Aug	705,551	32,649
Sep	1,720,618	274,944
Oct	1,593,266	4,798
Nov	1,567,147	0
Dec	690,323	0
Total Yearly Flows (cf) =	12,669,100	629,171
Total Yearly Flows (af) =	291	14
Ave Total Phosphorus (mg/l) =	0.200	0.320
Total Phosphorus (lb) =	158	13
Ave Total Suspended Solids (mg/l) =	53	59
Total Suspended Solids (lb) =	42,184	2,298
Total Suspended Solids (tons) =	21	1
Estimated TP Removal Efficiency =	92%	
Estimated TSS Removal Efficiency =	95%	

J. Summary of Measured Inflow Loads

Monitoring period generally May through November or December for 1996.

Event Type	Runoff Volume (AF)	Percent of Total Runoff Volume	TSS (mg/l)	TSS (tons)	Percent of Total TSS	TP (mg/l)	TP (lbs)	Percent of Total TP
Base flow	123	61%	5	1	5%	0.139	46	42%
Storm flow	77	39%	135	14	95%	0.302	64	58%
Total	200			15			110	

K. Estimated Average Annual Inflow Loads

Monitoring period generally May through November or December for 1996.

Event Type	Runoff Volume (af/yr)	Percent of Total Runoff Volume	TSS (mg/l)	TSS (tons/yr)	Percent of Total TSS	TP (mg/l)	TP (lbs/yr)	Percent of Total TP
Base flow	182	63%	5	1	5%	0.139	69	43%
Storm flow	109	37%	135	20	95%	0.302	89	57%
Total	291			21			158	

L. Unit Inflow Loading Rates

Drainage Area = 560 ac *Mixed urban land use*

Average annual precip = 15.18 in

Event Type	Runoff Volume (af/ac)	Percent Runoff	TSS (tons/ac)	TP (lb/ac)
Base flow	0.325	26%	0.0021	0.123
Storm flow	0.195	15%	0.0356	0.160
Total	0.519	41%	0.0377	0.283

M. Average Annual Loads Removed by System

Event Type	Estimated TSS Removal Efficiency	TSS In (tons/yr)	TSS Removed (tons/yr)	TSS Out (tons/yr)	Estimated TP Removal Efficiency	TP In (lb/yr)	TP Removed (lb/yr)	TP Out (lb/yr)
Base flow	75%	1	1	0	75%	69	52	17
Storm flow	84%	20	17	3	59%	89	53	37
Total	84%	21	18	3	66%	158	104	54

Notes:

TSS/TP Base Flow Removal Efficiencies: For long term average assume 75% of 1996 data.

TSS Storm Flow Removal Efficiency: Theoretical 2-year TSS removal efficiency based on dynamic sedimentation.

TP Storm Flow Removal Efficiency: Assumed as 70% of TSS removal efficiency based on 1990-1992 Shop Creek data.

Project: Cherry Creek Basin Water Quality Authority
Nonpoint Source Evaluation
Cottonwood Creek

Date: 1/29/97

A. Examination of Raw Data for Cottonwood Creek Site 1 (1994-1996)

	Storm Event	Sample Type	Total Suspended Solids (mg/l)	Total Suspended Solids (lb)	Total Phosphorus (mg/l)	Total Phosphorus (lb)	Runoff Peak Discharge (cfs)	Runoff Volume (cf)	Comment on Flow Data
1	05/17/94	base	17	—	0.063	—	—	—	no flow data available
2	06/01/94	storm	698	6,250	0.478	4.3	4.02	143,424	small storm
3	06/14/94	base	21	184	0.059	0.5	1.7	140,456	base flow
4	06/19/94	base	413	5,690	0.152	2.1	4.23	220,680	receding end of storm
5	06/21/94	storm	65	2,490	0.159	6.1	30.33	613,682	arge storm
6	06/22/94	storm	176	13,184	0.181	13.6	83.92	1,199,866	arge storm
7	07/12/94	base	5	20	0.000	0.0	0.83	63,475	base flow
8	08/09/94	base	14	61	0.066	0.3	0.97	70,314	base flow
9	09/05/94	base	44	179	0.134	0.5	0.91	65,306	base flow
10	04/04/95	base	20	85	0.050	0.2	0.97	67,748	base flow
11	04/10/95	storm	1020	545	1.062	0.6	1.03	8,556	rising start of a storm
12	04/18/95	base	29	407	0.079	1.1	5.06	224,543	rising start of a storm
13	04/18/95	storm	106	1,486	0.097	1.4	5.06	224,543	arge storm
14	04/23/95	storm	372	4,664	0.356	4.5	5.45	200,812	small storm
15	05/02/95	base	15	—	0.040	—	—	—	no flow data available
16	05/02/95	storm	826	—	0.098	—	—	—	no flow data available
17	05/16/95	base	12	—	0.028	—	—	—	no flow data available
18	05/16/95	storm	761	—	0.651	—	—	—	no flow data available
19	05/30/95	probably storm	1040	—	0.100	—	—	—	No flow data. Shop Creek data indicates storm
20	06/13/95	base	15	136	0.105	1.0	3.18	145,683	base flow
21	06/27/95	base	12	162	0.060	0.8	2.70	215,739	base flow
22	07/11/95	base	13	149	0.062	0.7	2.53	183,034	base flow
23	07/13/95	storm	167	1,909	0.245	2.8	2.81	183,129	small storm
24	07/25/95	base	11	154	0.069	1.0	3.18	224,209	base flow
25	08/08/95	base	18	192	0.197	2.1	2.24	170,911	base flow
26	08/22/95	base	36	405	0.134	1.5	2.38	180,058	base flow
27	08/13/95	storm	86	1,001	0.170	2.0	2.46	186,400	small storm
28	08/17/95	storm	580	6,135	0.802	8.5	2.18	169,432	arge storm
29	09/06/95	base	16	187	0.070	0.8	2.45	187,707	base flow
30	09/18/95	storm	392	4,207	3.150	33.8	2.08	171,922	arge storm
31	09/20/95	storm	150	4,015	0.360	9.6	35.15	428,703	arge storm
32	09/29/95	storm	148	2,237	0.040	0.6	6.57	242,102	arge storm
33	10/03/95	base	18	249	0.090	1.2	2.69	221,901	base flow
34	10/03/95	storm	126	1,745	0.200	2.8	2.69	221,901	small storm
35	10/17/95	base	10	97	0.030	0.3	2.34	156,022	base flow
36	10/21/95	storm	64	560	0.170	1.5	1.7	140,237	small storm
37	10/31/95	base	4	50	0.020	0.2	2.67	199,544	base flow
38	04/02/96	base	12	—	0.042	—	—	—	no flow data available
39	04/16/96	base	9	—	0.052	—	—	—	no flow data available
40	04/30/96	base	12	53	0.010	0.0	0.86	70,501	base flow
41	05/09/96	storm	250	14,790	0.273	16.2	87.67	947,621	arge storm
42	05/14/96	base	37	131	0.087	0.3	0.77	56,649	base flow
43	05/24/96	storm	468	1,607	0.637	2.2	0.92	54,991	arge storm
44	05/28/96	base	62	360	0.267	1.6	1.22	93,001	base flow
45	06/11/96	base	18	51	0.072	0.2	0.61	45,521	base flow
46	06/14/96	storm	1160	3,439	1.240	3.7	0.62	47,493	arge storm
47	06/20/96	storm	681	2,246	0.649	2.1	0.72	52,825	small storm
48	06/25/96	base	16	53	0.096	0.3	0.69	52,982	base flow
49	07/09/96	base	18	88	0.105	0.5	11.52	78,653	small storm
50	07/08/96	storm	694	2,082	0.959	2.9	0.61	48,056	
51	07/23/96	base	206	432	0.140	0.3	0.48	33,614	base flow
52	07/24/96	storm	861	2,091	0.480	1.2	0.54	38,905	arge storm
53	08/06/96	base	13	19	0.052	0.1	0.32	23,734	base flow
54	08/07/96	storm	490	1,461	0.593	1.8	1.84	47,747	very small storm
55	08/20/96	base	16	28	0.055	0.1	0.38	28,422	base flow
56	09/03/96	base	33	52	0.080	0.1	0.35	25,166	base flow
57	09/11/96	storm	1100	7,508	0.101	0.7	18.81	109,334	arge storm
58	09/17/96	base	28	222	0.130	1.0	8.51	126,756	rising limb of a large storm
59	10/01/96	base	13	56	0.052	0.2	0.85	69,319	base flow
60	10/15/96	base	9	23	0.048	0.1	0.66	40,346	base flow
61	10/29/96	base	13	40	0.094	0.3	0.73	48,807	base flow

Note: The 5/30/95 grab sample was a "base" sample according to the raw data. However, the high TSS and TP values along with available flow data from Shop Creek, indicates that the grab sample may be more representative of a "storm" sample instead of a "base" sample. It is assumed for this analysis that the 5/30/95 grab sample represents a "storm" sample.

B. Raw Storm Flows Only

	Storm Event	Sample Type	Total Suspended Solids (mg/l)	Total Suspended Solids (lb)	Total Phosphorus (mg/l)	Total Phosphorus (lb)	Runoff Peak Discharge (cfs)	Daily Runoff Volume (cf)
1	06/01/94	storm	698	6,250	0.478	4.3	4.02	143,424
2	06/21/94	storm	65	2,490	0.159	6.1	30.33	613,682
3	06/22/94	storm	176	13,184	0.181	13.6	83.92	1,199,866
4	04/10/95	storm	1020	545	1.062	0.6	1.03	8,556
5	04/18/95	storm	108	1,486	0.097	1.4	5.06	224,543
6	04/23/95	storm	372	4,664	0.358	4.5	5.45	200,812
7	05/02/95	storm	826	—	0.098	—	—	—
8	05/16/95	storm	761	—	0.651	—	—	—
9	05/30/95	[illegible]	1040	—	0.100	—	—	—
10	07/13/95	storm	167	1,909	0.245	2.8	2.81	183,129
11	08/13/95	storm	86	1,001	0.170	2.0	2.46	186,400
12	08/17/95	storm	580	6,135	0.802	8.5	2.18	169,432
13	09/18/95	storm	392	4,207	3.150	33.8	2.08	171,922
14	09/20/95	storm	150	4,015	0.360	9.6	35.15	428,703
15	09/29/95	storm	148	2,237	[illegible]	[illegible]	6.57	242,102
16	10/03/95	storm	126	1,745	0.200	2.8	2.69	221,901
17	10/21/95	storm	64	560	0.170	1.5	1.70	140,237
18	05/09/96	storm	250	14,790	0.273	16.2	87.67	947,621
19	05/24/96	storm	468	1,607	0.637	2.2	0.92	54,991
20	06/14/96	storm	1160	3,439	1.240	3.7	0.62	47,493
21	06/20/96	storm	681	2,246	0.649	2.1	0.72	52,825
22	07/08/96	storm	694	2,082	0.959	2.9	0.61	48,056
23	07/24/96	storm	861	2,091	0.480	1.2	0.54	38,905
24	08/07/96	storm	490	1,461	0.593	1.8	1.84	47,747
25	09/11/96	storm	1100	7,508	0.101	0.7	18.81	109,334
		Totals	12481	85,651	[illegible]	[illegible]	297.2	5,481,881
	Averages (Mathematical)		499	3,893	[illegible]	[illegible]	13.5	249,167

Note: The TP concentration for the 9/30/95 storm appears to be unusually low, therefore, it was not included the calculations for average and total TP concentrations and loads (values w/shaded background).

C. Raw Base Flows Only

	Storm Event	Sample Type	Total Suspended Solids (mg/l)	Total Suspended Solids (lb)	Total Phosphorus (mg/l)	Total Phosphorus (lb)	Runoff Peak Discharge (cfs)	Daily Runoff Volume (cf)
1	05/17/94	base	17	—	0.063	—	—	—
2	06/14/94	base	21	184	0.059	0.5	1.7	140,456
3	06/19/94	base	413	5,690	0.152	2.1	4.23	220,680
4	07/12/94	base	5	20	0.000	0.0	0.83	63,475
5	08/09/94	base	14	61	0.068	0.3	0.97	70,314
6	09/05/94	base	44	179	0.134	0.5	0.91	65,306
7	04/04/95	base	20	85	0.050	0.2	0.97	67,748
8	04/18/95	base	29	407	0.079	1.1	5.06	224,543
9	05/02/95	base	15	—	0.040	—	—	—
10	05/16/95	base	12	—	0.028	—	—	—
11	06/13/95	base	15	136	0.105	1.0	3.18	145,683
12	06/27/95	base	12	162	0.060	0.8	2.7	215,739
13	07/11/95	base	13	149	0.062	0.7	2.53	183,034
14	07/25/95	base	11	154	0.069	1.0	3.18	224,209
15	08/08/95	base	18	192	0.197	2.1	2.24	170,911
16	08/22/95	base	36	405	0.134	1.5	2.38	180,058
17	09/06/95	base	16	187	0.070	0.8	2.45	187,707
18	10/03/95	base	18	249	0.090	1.2	2.69	221,901
19	10/17/95	base	10	97	0.030	0.3	2.34	156,022
20	10/31/95	base	4	50	0.020	0.2	2.67	199,544
21	04/02/96	base	12	—	0.042	—	—	—
22	04/16/96	base	9	—	0.052	—	—	—
23	04/30/96	base	12	53	0.010	0.0	0.86	70,501
24	05/14/96	base	37	131	0.087	0.3	0.77	56,649
25	05/28/96	base	62	360	0.267	1.6	1.22	93,001
26	06/11/96	base	18	51	0.072	0.2	0.61	45,521
27	06/25/96	base	16	53	0.096	0.3	0.69	52,982
28	07/09/96	base	18	88	0.105	0.5	11.52	78,653
29	07/23/96	base	206	432	0.140	0.3	0.48	33,614
30	08/06/96	base	13	19	0.052	0.1	0.32	23,734
31	08/20/96	base	16	28	0.055	0.1	0.38	28,422
32	09/03/96	base	33	52	0.080	0.1	0.35	25,166
33	09/17/96	base	28	222	0.130	1.0	8.51	126,756
34	10/01/96	base	13	56	0.052	0.2	0.85	69,319
35	10/15/96	base	9	23	0.048	0.1	0.66	40,346
36	10/29/96	base	13	40	0.094	0.3	0.73	48,807
		Totals	1,258	10,015	2.890	19.6	68.98	3,530,801
	Averages (Mathematical)		35	323	0.080	0.6	2.23	113,897

D. Total Monthly Storm Flows (Measured)

Month	Runoff Volumes (cf) 1994	1995	1996	Total	Ave. Annual
Jan	—	—	—	0	
Feb	—	—	—	0	
Mar	—	—	—	0	
Apr	—	[illegible]	0	5,343,205	
May	—	—	7,933,972	7,933,972	
Jun	5,660,792	[illegible]	1,614,208	16,835,311	
Jul	0	6,579,803	3,569,346	10,149,149	
Aug	303,517	2,212,608	149,247	2,665,372	
Sep	0	7,705,959	3,698,733	11,404,692	
Oct	869,996	2,228,449	259,115	3,357,560	
Nov	[illegible]	1,279,164	0	1,279,164	
Dec	—	[illegible]	0	0	
Total Yearly Flows (cf) =	6,834,305	34,909,499	17,224,621	58,968,425	19,656,142
Total Yearly Flows (af) =	157	801	395	1,354	451
Ave Total Phosphorus (mg/l) =	0.530	0.530	0.530	—	0.530
Total Phosphorus (lb) =	226	1,155	570	1,951	650
Ave Total Suspended Solids (mg/l) =	499	499	499	—	499
Total Suspended Solids (lb) =	213,005	1,088,025	536,840	1,837,870	612,623
Total Suspended Solids (tons) =	107	544	268	919	306

Note: Only partial flow data was available for months with light shaded background. Total runoff volumes for these months were estimated by interpolation of the partial flow data available.

E. Total Monthly Base Flows (Measured)

Month	Runoff Volumes (cf) 1994	1995	1996	Total	Ave. Annual
Jan	—	—	—	0	
Feb	—	—	—	0	
Mar	—	—	—	0	
Apr	—	[illegible]	[illegible]	3,434,404	
May	—	—	1,676,596	1,676,596	
Jun	2,314,711	[illegible]	1,548,141	9,008,385	
Jul	2,904,034	4,166,661	1,079,875	8,150,570	
Aug	2,167,522	4,253,312	867,472	7,288,306	
Sep	2,154,102	4,014,604	1,151,322	7,320,028	
Oct	1,825,166	3,709,287	1,381,501	6,915,954	
Nov	[illegible]	5,322,748	1,272,172	8,545,911	
Dec	—	[illegible]	[illegible]	8,900,599	
Total Yearly Flows (cf) =	13,316,528	35,447,605	12,476,622	61,240,753	20,413,584
Total Yearly Flows (af) =	306	814	286	1,406	469
Ave Total Phosphorus (mg/l) =	0.080	0.080	0.080	—	0.080
Total Phosphorus (lb) =	67	178	63	307	102
Ave Total Suspended Solids (mg/l) =	35	35	35	—	35
Total Suspended Solids (lb) =	29,051	77,331	27,218	133,599	44,533
Total Suspended Solids (tons) =	15	39	14	67	22

Note: Only partial flow data was available for months with light shaded background. Total runoff volumes for these months were estimated by interpolation of the partial flow data available.

F. Total Monthly Storm and Base Flows (Measured)

Month	Runoff Volumes (cf) 1994	1995	1996	Total	Ave. Annual
Jan	—	—	—	0	
Feb	—	—	—	0	
Mar	—	—	—	0	
Apr	—	[illegible]	[illegible]	8,777,609	
May	—	—	9,610,568	9,610,568	
Jun	7,975,503	[illegible]	3,162,349	25,843,696	
Jul	2,904,034	10,746,464	4,649,221	18,299,719	
Aug	2,471,039	6,465,920	1,016,719	9,953,678	
Sep	2,154,102	11,720,563	4,850,055	18,724,720	
Oct	2,695,162	5,937,736	1,640,616	10,273,514	
Nov	[illegible]	6,601,912	1,272,172	9,825,075	
Dec	—	[illegible]	[illegible]	8,900,599	
Total Yearly Flows (cf) =	20,150,831	70,357,104	29,701,243	120,209,178	40,069,726
Total Yearly Flows (af) =	463	1,615	682	2,760	920
Ave Total Phosphorus (mg/l) =	0.233	0	0.341	—	0.301
Total Phosphorus (lb) =	293	1,333	632	2,258	753
Ave Total Suspended Solids (mg/l) =	192	265	304	—	263
Total Suspended Solids (lb) =	242,056	1,165,356	564,059	1,971,470	657,157
Total Suspended Solids (tons) =	121	583	282	986	329

Note: Only partial flow data was available for months with light shaded background. Total runoff volumes for these months were estimated by interpolation of the partial flow data available.

G. Total Monthly Storm Flows (Estimated)

Month	Runoff Volumes (cf) 1994	1995	1996	Total	Ave. Annual	Denver Average Monthly Rainfall (ft)	(in)	(% of total)
Jan	[illegible]	[illegible]	[illegible]	2,468,253		0.0360	0.43	2.8%
Feb	[illegible]	[illegible]	[illegible]	2,982,473		0.0435	0.52	3.4%
Mar	[illegible]	[illegible]	[illegible]	7,288,203		0.1063	1.28	8.4%
Apr	[illegible]	5,343,205	0	6,738,047		0.1326	1.59	10.5%
May	[illegible]	[illegible]	7,933,972	21,052,184		0.2494	2.99	19.7%
Jun	5,660,792	9,560,311	1,614,208	16,835,311		0.1495	1.79	11.8%
Jul	0	6,579,803	3,569,346	10,149,149		0.1228	1.47	9.7%
Aug	303,517	2,212,608	149,247	2,665,372		0.1190	1.43	9.4%
Sep	0	7,705,959	3,698,733	11,404,692		0.1094	1.31	8.6%
Oct	869,996	2,228,449	259,115	3,357,560		0.0787	0.94	6.2%
Nov	0	1,279,164	0	1,279,164		0.0703	0.84	5.6%
Dec	[illegible]	0	0	497,557		0.0473	0.57	3.7%
Total Yearly Flows (cf) =	13,304,647	53,222,679	20,190,640	86,717,966	28,905,989	1.2648	15.18	100%
Total Yearly Flows (af) =	305	1,222	464	1,991	664			
Ave Total Phosphorus (mg/l) =	0.530	0.530	0.530	—	0.530			
Total Phosphorus (lb) =	440	1,761	668	2,869	956			
Ave Total Suspended Solids (mg/l) =	499	499	499	—	499			
Total Suspended Solids (lb) =	414,666	1,658,793	629,282	2,702,741	900,914			
Total Suspended Solids (tons) =	207	829	315	1,351	450			

Note: Total runoff volumes shown with shaded background were estimated by linear interpolation using the average monthly rainfall data for Denver.

H. Total Monthly Base Flows (Estimated)

Assumed % of winter (unmeasured) base flows to summer (measured) base flows = 67% (value calibrated to average Denver precipitation)

Month	Runoff Volumes (cf) 1994	1995	1996	Total	Ave. Annual
Jan	[illegible]	[illegible]	[illegible]	5,384,564	
Feb	[illegible]	[illegible]	[illegible]	5,384,564	
Mar	[illegible]	[illegible]	[illegible]	5,384,564	
Apr	[illegible]	1,251,989	2,182,415	4,921,416	
May	[illegible]	[illegible]	1,676,596	6,132,345	
Jun	2,314,711	5,145,533	1,548,141	9,008,385	
Jul	2,904,034	4,166,861	1,079,875	8,150,570	
Aug	2,167,522	4,253,312	867,472	7,288,306	
Sep	2,154,102	4,014,604	1,151,322	7,320,028	
Oct	1,825,166	3,709,287	1,381,501	6,915,954	
Nov	1,950,991	5,322,748	1,272,172	8,545,911	
Dec	[illegible]	7,583,471	1,317,128	10,387,611	
Total Yearly Flows (cf) =	22,238,598	47,322,553	15,263,068	84,824,219	28,274,740
Total Yearly Flows (af) =	511	1,086	350	1,947	649
Ave Total Phosphorus (mg/l) =	0.080	0.080	0.080	—	0.080
Total Phosphorus (lb) =	111	237	76	425	142
Ave Total Suspended Solids (mg/l) =	35	35	35	—	35
Total Suspended Solids (lb) =	48,514	103,236	33,297	185,048	61,683
Total Suspended Solids (tons) =	24	52	17	93	31

Note: Base flow volumes for the unmeasured months (winter) were estimated assuming 67% of the average monthly base flow for the measured months (summer).

I. Total Monthly Storm and Base Flows (Estimated)

Month	Runoff Volumes (cf) 1994	1995	1996	Total	Ave. Annual
Jan	1,865,702	4,483,614	1,503,501	7,852,817	
Feb	1,944,596	4,799,213	1,623,228	8,367,037	
Mar	2,605,200	7,441,832	2,625,736	12,672,768	
Apr	2,881,854	6,595,194	2,182,415	11,659,463	
May	4,110,493	13,463,468	9,610,568	27,184,529	
Jun	7,975,503	14,705,844	3,162,349	25,843,696	
Jul	2,904,034	10,746,464	4,649,221	18,299,719	
Aug	2,471,039	6,465,920	1,016,719	9,953,678	
Sep	2,154,102	11,720,563	4,850,055	18,724,720	
Oct	2,895,162	5,937,736	1,640,616	10,273,514	
Nov	1,950,991	6,601,912	1,272,172	9,825,075	
Dec	1,984,569	7,583,471	1,317,128	10,885,168	
Total Yearly Flows (cf) =	35,543,245	100,545,231	35,453,708	171,542,184	57,180,728
Total Yearly Flows (af) =	816	2,308	814	3,938	1,313
Ave Total Phosphorus (mg/l) =	0.249	0.318	0.336	—	0.308
Total Phosphorus (lb) =	552	1,998	745	3,295	1,098
Ave Total Suspended Solids (mg/l) =	209	281	299	—	270
Total Suspended Solids (lb) =	463,181	1,762,029	662,579	2,887,789	962,596
Total Suspended Solids (tons) =	232	881	331	1,444	481

J. Summary of Measured Inflow Loads

Monitoring period generally April through December for the years 1994, 1995, and 1996

Event Type	Runoff Volume (AF)	Percent of Total Runoff Volume	TSS (mg/l)	TSS (tons)	Percent of Total TSS	TP (mg/l)	TP (lbs)	Percent of Total TP
Base flow	1406	51%	35	67	7%	0.080	307	14%
Storm flow	1354	49%	499	919	93%	0.530	1951	86%
Total	2760			986			2258	

K. Estimated Average Annual Inflow Loads

Event Type	Runoff Volume (af/yr)	Percent of Total Runoff Volume	TSS (mg/l)	TSS (tons/yr)	Percent of Total TSS	TP (mg/l)	TP (lbs/yr)	Percent of Total TP
Base flow	649	49%	35	31	6%	0.080	142	13%
Storm flow	664	51%	499	450	94%	0.530	956	87%
Total	1313			481			1098	

L. Unit Loading Rates

Drainage Area = 8740 ac

Average annual precip = 15.18 in

Mixed urban/undeveloped land use

Event Type	Runoff Volume (af/ac)	Percent Runoff	TSS (tons/ac)	TP (lb/ac)
Base flow	0.074	6%	0.004	0.016
Storm flow	0.076	6%	0.052	0.109
Total	0.150	12%	0.055	0.126

M. Average Annual Loads Removed by System

Event Type	Estimated TSS Removal Efficiency	TSS In (tons/yr)	TSS Removed (tons/yr)	TSS Out (tons/yr)	Estimated TP Removal Efficiency	TP In (lb/yr)	TP Removed (lb/yr)	TP Out (lb/yr)
Base flow	15%	31	5	26	5%	142	7	135
Storm flow	64%	450	288	162	45%	956	430	526
Total	61%	481	293	188	40%	1098	438	661

Notes:

TSS/TP Base Flow Removal Efficiencies: Assumed 25% of Shop Creek base flow removal efficiency.

TSS Storm Flow Removal Efficiency: Theoretical 2-year TSS removal efficiency based on dynamic sedimentation.

TP Storm Flow Removal Efficiency: Assumed as 70% of TSS removal efficiency based on 1990-1992 Shop Creek data.