Appendix 6-C

Canal Seepage Estimates

Appendix 6-C provides information on the approach used to estimate canal seepage rates with an example application of the approach for Gothenburg Canal. Also included is summary of seepage rate estimates by canal and a short description of how seepage volumes computed by the surface water model are addressed.

COHYST 2010

Development of Irrigation Canal Seepage Estimates

One of the key water budget elements represented by the surface water model is the seepage from irrigation canals. Unfortunately, very little field data on seepage rates for the irrigation canals within the model domain is available. Single daily data point measurements have been collected as part of synoptic studies at select canal locations as described in Section 4.4.2.1. While this data is useful, it is too sparse both temporally and spatially to use in developing definitive estimates of irrigation canal seepage rates.

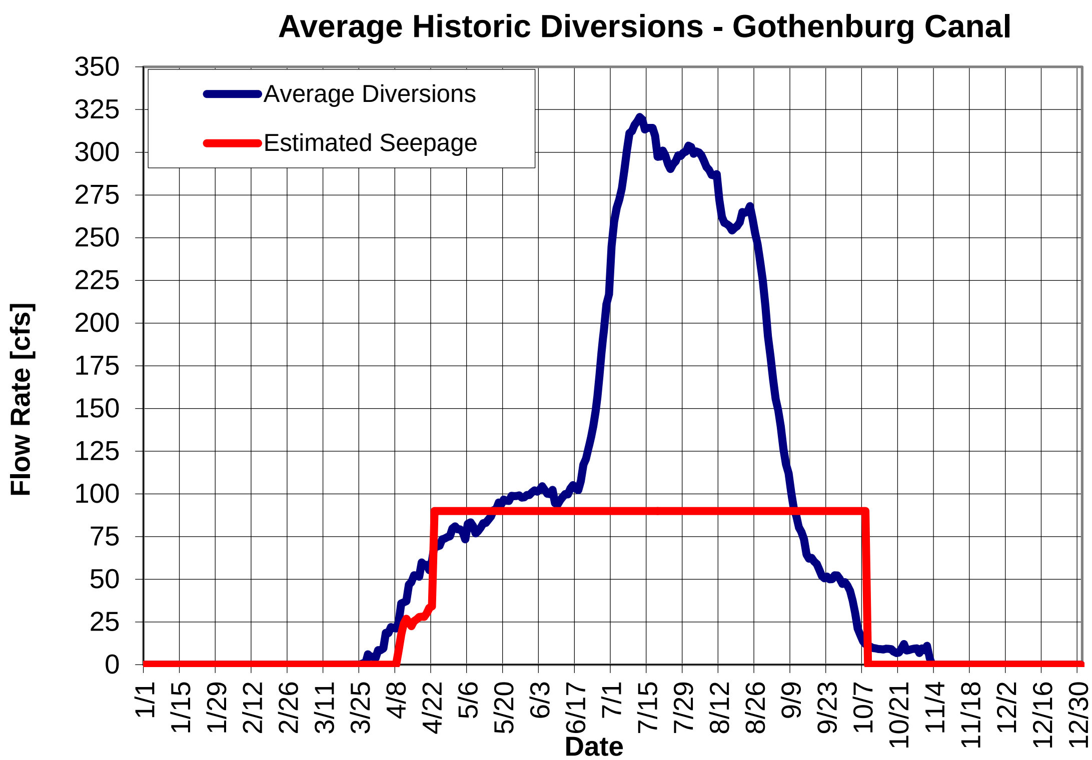
The approach to estimate irrigation canal seepage rates for the COHYST 2010 modeling effort partitions the diversion season into two parts: 1) the initial filling period, and 2) the remainder of the diversion season.

As discussed in Section 6.6.1, during the initial filling period, the irrigation canal is assumed to fill over the initial two weeks based on review of historic diversion records and discussions with operators. Based on these early season diversion pattern, the initial filling seepage rate is estimated as 50% of the diversion rate. This seepage estimate reflects the 'charging' of the canal as it initially fills.

Once the canal is charged, a constant seepage rate is used through the remainder of the non-irrigation season and the irrigation season. This approach is based on the assumption that the canals are head-driven system and therefore are largely independent of the actual flow rate in the canal. The estimated constant seepage rates used for the remaining of the diversion season following initial filling were determined by evaluating historic diversion patterns – specifically the mid-May to mid-June period when the canals are charged and diversions are made to essentially maintain canal levels (diversion = seepage). The estimated seepage rate is not based on mathematical calculations, but rather on a visual inspection of the historical data and engineering judgment.

Figure 1 provides an illustrative example of this approach for the Gothenburg Canal. The variable seepage rate for the two-week (50% of historic diversion rate), initial filling period is clearly visible at the beginning of the diversion season. Following the initial filling period and prior to the initiation of crop deliveries, the approximate daily diversion from the historic record is 100 cfs. Assuming approximately 10 percent losses to spills and evaporation, 90 cfs is the estimated seepage rate seepage rate from the Gothenburg Canal from the completion of initial filling through the end of the diversion season.

Figure 1. Gothenburg Canal Average Daily Diversion Rate



As a verification of this seepage rate estimate for Gothenburg Canal, the synoptic study data was referenced and summarized in Table 1. The estimated constant seepage rate is well within reasonable limits of the synoptic study results and appropriate for use in the model.

Table 1. Gothenburg Canal – Results of Synoptic Study Seepage Estimates.

Sampling Date	Main/Supply Canal Seepage [cfs]	Lateral Seepage [cfs]	Estimated Total Seepage [cfs]
July 27, 2004	66.1	23.1	89.2
August 10, 2004	80.4	20.1	100.5
		AVERAGE =	94.85

This same approach was applied to each irrigation canal to derive estimated constant seepage rate estimates for use in the model. It is noted that logic statements have been incorporated into the STELLA model to check to make sure that diversions into the canal are non-zero before applying a seepage rate.

Table 2 summarizes the estimated seepage rates for each canal within the extents of the surface water model, including the irrigation canal seepage returns determined using the approach contained herein.

River	Canal	Seepage (cfs)
North Platte River	Keith Lincoln Canal	29
	North Platte Canal	72
	Paxton Hershey Canal	31
	Suburban Canal	40
	Cody Dillon Canal	5
	Birdwood Canal	14
	Keystone/Sutherland Canal	
South Platte River	Western Canal	63
	Korty/Sutherland Canal	RR STUDY***
Platte River	Tri County Canal - CNPPID Supply Canal	see below
	-Phelps County Canal	250
	-E65 Canal	125
	-E67 Canal	25
	Gothenburg Canal	90
	Cozad Canal	31
	Dawson County Canal	103
	Thirty Mile Canal	72
	Six Mile Canal	3
	Orchard Alfalfa Canal	16
	Kearney Canal	16

Tri- County Supply Canal Seepage (cfs) (varies by segment based on diversion at headgate)	Diversion at Headgate (cfs)			
	< 1,000	1,000 – 1,500	1,500 – 2,000	> 2,000
Headgate to Jeffrey Reservoir	39	69	99	129
Jeffry Hydro to J1 Hydro	150	210	250	350
J1 Hydro to J2 Hydro	10			
J2 Hydro to J2 Return	-20			

Canal and Lateral Recharge

One of the key water budget components that the STELLA model is responsible is the canal and reservoir seepage that is part of the total recharge provided to the groundwater model. Figure 1 below illustrates a portion of the CNPPID system as an illustrative example of the proposed approach of the canal and reservoir seepage representation in STELLA.

The areas delineated in red represent reservoirs that will have seepage quantities year-around that will be estimated and exported from the STELLA model into a groundwater recharge file. Likewise, the green line represents the canal segments that are represented in the STELLA model and will have seepage quantities estimated during canal delivery and exported from the STELLA model into the same groundwater recharge file. Both canal and reservoir features are associated with the underlying ground water model grid so that the recharge quantities are directly associated with a grid cell underlying the canal/reservoir. The recharge file from STELLA containing the canal and reservoir seepage is combined with the recharge file from the watershed model (M. Groff's water partitioning work) to then create a total recharge file for the groundwater model.

You will notice in Figure 1 below that there are several smaller laterals (represented by the white lines) that are not represented in the STELLA model. The seepage from these laterals are not computed by the STELLA model, but rather are represented in the watershed model as part of the irrigation efficiency parameter. The watershed model distributes the computed lateral seepage over the area served by the canal lateral. This approach was used for each irrigation canal included in the STELLA model domain.

Figure 1