

reservoirs with detention times on the order of days and 1.0 log credit for reservoirs with detention times on the order of weeks. After a review of the available literature, EPA is unable to determine criteria that provide reasonable assurance of achieving a 0.5 or 1 log removal of oocysts. Consequently, EPA is not proposing a presumptive treatment credit for this process.

This proposal for off-stream raw water storage represents a change from the November 2001 pre-proposal draft of the LT2ESWTR (USEPA 2001g), which described 0.5 log and 1 log presumptive credits for reservoirs with hydraulic detention times of 21 and 60 days, respectively. These criteria were based on a preliminary assessment of reported studies, described later in this section,

that evaluated *Cryptosporidium* and *Giardia* removal in raw water storage reservoirs.

Subsequent to the November 2001 pre-proposal draft, the Science Advisory Board (SAB) reviewed the data that EPA had acquired to support *Cryptosporidium* treatment credits for off-stream raw water storage (see section VII.K). In written comments from a December 2001 meeting of the SAB Drinking Water Committee, the panel concluded that the available data were not adequate to demonstrate the treatment credits for off-stream raw water storage described in the pre-proposal draft, and recommended that no presumptive credits be given for this toolbox option. The panel did agree, though, that a utility should be able to take advantage of off-stream raw water

storage by sampling after the reservoir for appropriate bin placement. EPA concurs with this finding by the SAB and today's proposal is consistent with their recommendation.

Off-stream raw water storage can improve the microbial quality of water in a number of ways. These include (1) reduced microbial and particulate loading to the plant due to settling in the reservoir, (2) reduced viability of pathogens due to die-off, and (3) dampening of water quality and hydraulic spikes. EPA has evaluated a number of studies that investigated the removal of *Cryptosporidium* and other microorganisms and particles in raw water storage basins. These studies are summarized in the following paragraphs, and selected results are presented in Table IV-8.

TABLE IV-8.—STUDIES OF *Cryptosporidium* AND *GIARDIA* REMOVAL FROM OFF-STREAM RAW WATER STORAGE

Researcher	Reservoir	Residence time	Log reductions
Ketelaars et al. 1995	Biesbosch reservoir system: man-made pumped storage (Netherlands).	24 weeks (average)	<i>Cryptosporidium</i> -1.4 <i>Giardia</i> -2.3.
Van Breeman et al. 1998	Biesbosch reservoir system: man-made pumped storage (Netherlands).	24 weeks (average)	<i>Cryptosporidium</i> -2.0 <i>Giardia</i> -2.6.
Bertolucci et al. 1998	PWN (Netherlands)	10 weeks (average)	<i>Cryptosporidium</i> -1.3 <i>Giardia</i> -0.8.
	Abandoned gravel quarry used for storage (Italy).	18 days (theoretical)	<i>Cryptosporidium</i> -1.0 <i>Giardia</i> -0.8.
Ongerth, 1989	Three impoundments on rivers with limited public access (Seattle, WA).	40, 100 and 200 days (respectively).	No <i>Giardia</i> removal observed.

Ketelaars *et al.* (1995) evaluated *Cryptosporidium* and *Giardia* removal across a series of three man-made pumped reservoirs, named the Biesbosch reservoirs, with reported hydraulic retention times of 11, 9, and 4 weeks (combined retention time of 24 weeks). To prevent algal growth and hypolimnetic deoxygenation, the reservoirs were destratified by air-injection. Based on weekly sampling over one year, mean influent and effluent concentrations of *Cryptosporidium* were 0.10 and 0.004 oocysts/100 L, respectively, indicating an average removal across the three reservoirs of 1.4 log. Mean removal of *Giardia* was 2.3 log.

Van Breeman *et al.* (1998) continued the efforts of Ketelaars *et al.* (1995) in evaluating pathogen removal across the Biesbosch reservoir system. Using a more sensitive analytical method, Van Breeman *et al.* measured mean *Cryptosporidium* levels of 6.3 and 0.064 oocysts/100 L at the inlet and outlet, respectively, indicating an average removal of 2.0 log. For *Giardia*, the

average reduction was 2.6 log. In addition, Van Breeman *et al.* (1998) evaluated removal of *Cryptosporidium*, *Giardia*, and other microorganisms in a reservoir designated PWN, which had a hydraulic retention time of 10 weeks. Passage through this storage reservoir was reported to reduce the mean concentration of *Cryptosporidium* by 1.3 log and of *Giardia* by 0.8 log.

Bertolucci *et al.* (1998) investigated removal of *Cryptosporidium*, *Giardia*, and nematodes in a reservoir derived from an abandoned gravel quarry with a detention time reported as around 18 days. Over a 2 year period, average influent and effluent concentrations of *Cryptosporidium* were 70 and 7 oocysts/100 L, respectively, demonstrating a mean reduction of 1 log. Average *Giardia* levels decreased from 137 cysts/100L in the inlet to 46 cysts/100L at the outlet, resulting in a mean 0.5 log removal.

Ongerth (1989) studied concentrations of *Giardia* cysts in the Tolt, Cedar, and Green rivers, which drain the western slope of the Cascade Mountains in Washington. The watersheds of each

river are controlled by municipal water departments for public water supply, and public access is limited. The Cedar, Green, and Tolt rivers each have impoundments with reported residence times of 100, 30–50, and 200 days, respectively, in the reach studied. Ongerth found no statistically significant difference in cyst concentrations above and below any of the reservoirs. Median cyst concentrations above and below the Cedar, Green, and Tolt reservoirs were reported as 0.12 and 0.22, 0.27 and 0.32, and 0.16 and 0.21 cysts/L, respectively. It is unclear why no decrease in cyst levels was observed. It is possible that contamination of the water in the impoundments by *Giardia* from animal sources, either directly or through runoff, may have occurred.

EPA has also considered results from studies which evaluated the rate at which *Cryptosporidium* oocysts lose viability and infectivity over time. Two studies are summarized next, with selected results presented in Table IV-9.