midge (*Chronomus tentans)* and clam (*Corbicuela fluminea).* Obviously, these lethal temperatures, that are in the range shown on Figure 2.44, reflect only on the two test organisms.

The results of these studies pertinent to establishing the temperature limits are:

> The test amphipod and fish were the more sensitive species to thermal effects. In seven days exposure to water temperature of 33°C (91.4 °F) or greater, significant amphipod mortality occurred; however, fish survival was only slightly effected. A temperature of 34°C (93.2 °F) lasting for seven days; however, was lethal to both amphipod and fish. The authors concluded that "it would appear that the 33°C to 34°C temperature is the critical range if exposures extend for a period of at least 7 days. **The current Secondary Contact and Indigenous Aquatic Life temperature standard allows high temperatures exceeding this lethal threshold to last more than 18 days.**

We are aware of the fact that the objective and purpose of the Wright University study was not to establish thermal limits but to document the impact of contaminated sediments (see also Chapter 3). Nevertheless, the experiment did show significant lethal effects of high temperatures when compared to sediment effects at temperatures at or lower than 30°C.

Figures 2.44 and 2.45 and the above discussion document the Secondary Contact Indigenous Aquatic Life temperature standard is at or above the lethal temperature of all warmwater fish species. These reported lethal limits are mostly for adult fishes. The lethal temperature limits are generally less for juveniles. In defending this secondary use temperature standard, arguments were made that the fish can escape from the regions of high temperature. This may be correct for adult fish. As a matter of fact, Jones (1964) stated in his treatise on fish and thermal pollution that: " Whether fish are killed in significant numbers by thermal discharges is doubtful, but they may disappear from heated regions of rivers, at least during the warm months of the year." However, the same argument can be used for some other pollutants such as dissolved oxygen, yet, the standards of DO are strictly enforced and no one would suggest downgrading the DO standard into the lethal zone based on the argument that fish could escape. Hence, the outcome of the current high temperatures in the Upper Dresden pool is most likely a summer migration of fish to colder waters. Similar effect was observed on the Delaware River. Trembley (1960) studied the effect of heated discharges into an otherwise unpolluted stretch of the Delaware River, which resulted in summer maximum temperatures exceeding 38 °C (100 °F) in the river 1500 feet downstream of the heated discharge. He found that most species were eliminated from the zone of maximum temperature during the warmer months. However, during the colder months, fish returned to the heated waters. The disappearance of fish from heated zones obviously affects the Indices of Biotic Integrity. Only adult fish are known to escape the impact of high temperatures. The effect on juvenile fish that may migrate from upstream after spawning during spring colder months is not certain. Other organisms (e.g., benthic macroinvertebrates) cannot escape.

Comparison with thermal standards of other states. We have also surveyed the temperature standards of all states in the nation. Forty-seven states do not allow the temperature to exceed 32°C (90°F) even in marginal waters, including southern states (USEPA, 1988). Two states (Nebraska and

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Idaho) allow 34 and 33°C, respectively; however, only in the lowest quality marginal streams to prevent a nuisance. Nineteen states have the maximum temperature standard of 32°C. The maximum temperature standard in the remaining states (excluding Illinois) is less than 32°C. This standard (i.e., 32°C or 90°F) does provide protection from lethal effects, as shown on Figures 2.44 and 2.45. In our Water Body Assessment throughout this chapter and this UAA, we have presented evidence that the Lower Des Plaines River is a recovering stream with some ecological potential and cannot have standards that in other states would be classified as"marginal" or "nuisance". This is the main difference between the current situation and the situation almost thirty years ago when the Lower Des Plaines River appeared to be hopelessly polluted and installation of cooling systems was deemed to have no ecological benefits.

In the current context of the standards development for aquatic life protection and propagation, a standard must be developed so that the organisms not only survive, it must provide for fish propagation and the well being of organisms that could potentially reside in the reach. The lack of this protection and allowing the standard to be in the lethal zone is a problem with the Illinois Secondary Contact and Indigenous Aquatic Life standard for temperature (and also for other parameters, see Table 2.1 and evaluation in Chapter 8). It does not provide for fish and other organisms propagation and does not protect the potentially indigenous organisms from lethal effects. Because the magnitude of the Secondary Contact and Indigenous Aquatic Life Use temperature standard in Illinois is beyond the lethal effect, it only provides illusionary compliance with a number that does not have much meaning and provides no protection.

Existing Use - Compliance With the General Use Standard

Figure 2.46 presents the temperature chart replotted from the Midwest Generation's presentation to the biological subcommittee for the period 1999-2000. The plot contains measurements at the I-55 bridge and at the two discharge channels, Station 29 located on the right bank and Station 9 on the left bank. No continuous measurements of temperature are carried out in the about 7-mile stretch of the river itself between the cooling water discharge outlets and the I-55 bridge (MWRD93 grab sampling location is the only monitoring point in this stretch). At the meeting on June 6, 2003 between the consultants, IEPA and Midwest Generation, it was revealed that the high temperatures in the discharge canal of Station 29 exceeding 100°F were measured at the condenser discharge location. The flow in the canal was then cooled down by the operation side stream cooling towers on the canal; however, no measurements were made at the canal outlet into the river. Midwest Generation calculated the discharge canal temperature at the confluence with the river based on the number of towers in operation, reported condensed circulation water flow and 14°F delta T across the cooling tower. These calculated maximum daily temperatures for the period July - August 1999 ranged between 93 and 98°F. A violation of the maximum Secondary Use and Indigenous Aquatic Life maximum temperature standard cannot be alleged. Midwest Generation consultants periodically conduct survey of the river. Figure 2.47 shows a plot of ranges of the temperatures in the Lower Des Plaines River in 2001 (a warm year) measured by the EA Engineering, Science and Technology in the river. Data were provided after the request made at the June 6th, 2003 meeting between the consultants and Midwest Generation. The highest temperatures near 37.8 °C (100 °F) were measured in the zone near the discharge canal.

The hourly temperature data measurement during the 1999 at the I-55 period reported by EA Engineering Science and Technology (2000) and Midwest Generation show that the original (statewide) General Use standard would not have been met because at the I-55 location:

- the maximum temperature reached 93°F (permitted under the present adjusted ~~variance~~ and the statewide General use standards); however,
- the total number of hours during which the temperature exceeded 90°F was about 200, which is about 2.3% while only 1% would have been allowed if the original general standard had been in force.

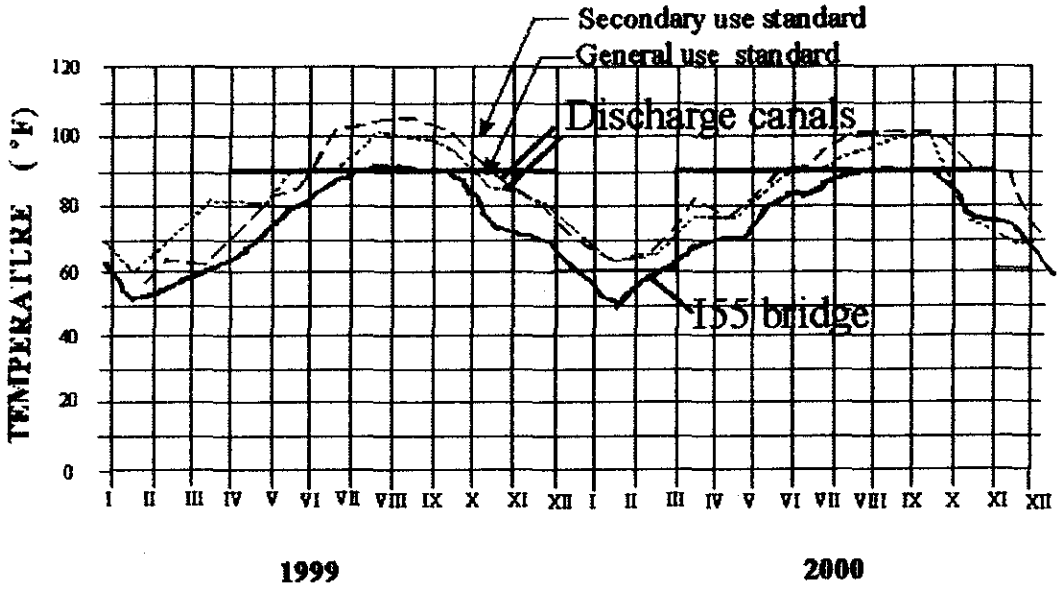

Figure 2.46 Maximum monthly temperatures at the condenser outlets into the discharge canals of the Joliet power plant units and at the I-55 bridge. Replotted from the Midwest Generation presentation materials to the UAA biological subcommittee.

The more lenient adjusted standard for the I-55 location was met.

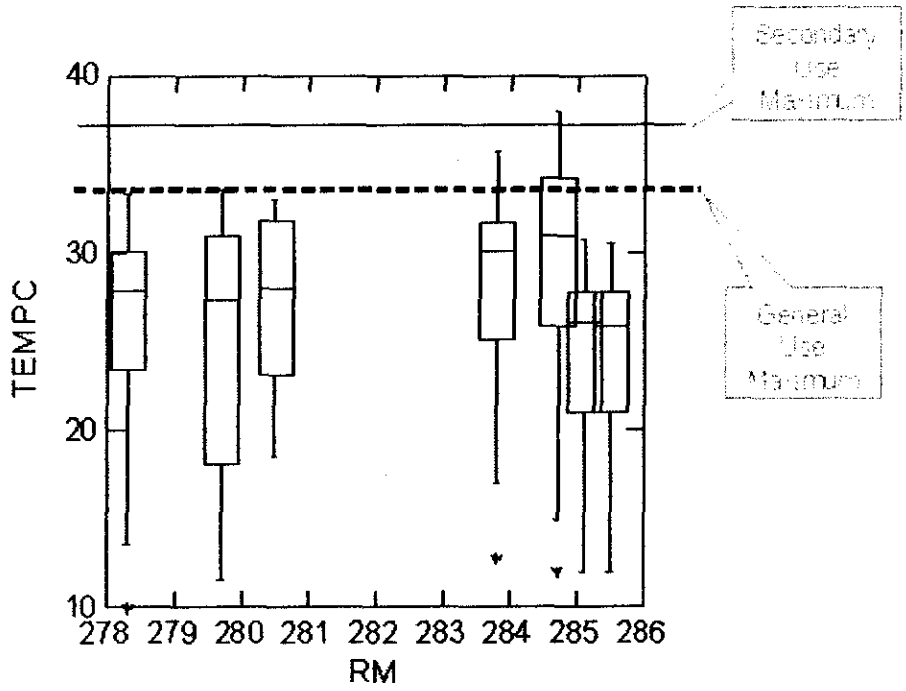

Figure 2.47 Temperatures measured in the Upper Dresden Island Pool during surveys by the Midwest Generation consultants. Data courtesy of Midwest generation and EA Engineering Science and Technology

We have not directly addressed the second part of the temperature standard, i.e., the maximum thermal differential (delta T) of 5°F (3°C) and the effect of thermal discharges on temperature in the river during very low flows nearing the 7Q10. Again, if the temperature rise (calculated by Holly and Bradley[1994] assuming no effect of later installed cooling towers on the canal of Station 29 see Table 1.2) through the condenser of 9.4°F at the river flow of 2850 caused a river temperature differential of 6.7°F, it is quite likely that at smaller flows (e.g., approaching 7Q10 flow) the temperature differential would be greater than 6.7°F, approaching the condenser temperature differential. Since the cooling towers can only effectively cool down only 1/3 to ½ of the Station 29 flow, it will be difficult to meet the delta T standard during very low flows. Due to the fact that no continuous measurements are available for the above and below temperature of the river the delta T criterion cannot be accurately assessed for the river.

Arguments have been made that this differential is between the river flow and a "natural" temperature of the river and there is no "natural " temperature in the Lower Des Plaines River. This is due to the confusing wording of the Illinois General Use standard. In many other states, standards for the temperature differential were introduced to prevent thermal barriers from forming in the river by thermal discharges so that passage of fish and other biota up and down the river would be

possible. Such thermal differential standard is applied to the upstream and downstream temperatures. The notion of natural temperature is typically included for cases when the natural temperature itself may get higher.

Conclusion on Temperature

Temperature is one of the more significant parameters being addressed in this study, particularly within the Dresden Island pool. Temperature has been repeatedly addressed by the Pollution Control Board since the original standards were established in 1973 and as recently as 1996. In light of significant operational and financial impact thermal standards have on Midwest Generation's facilities; Illinois EPA requested that this analysis addresses two specific issues and defer a recommendation on proposed future standards such that Midwest Generation and other river users could contribute to the socio-economic factors. A socio-economic analysis and detemination whether the impact on the dischargers of heated effluents on the Lower Des Plaines River would incur a substantial and wide spread adverse socio-economic impact on the utilities and the population was not performed in this study but is crucial. It is the only reason a departure from the Illinois General Use standard can be justified. This study has concluded that the first five reasons by themselves, cannot be applied to downgrade the thermal standard from that specified by the Illinois General Use standards.

The two specific issues addressed to be addressed in this UAA are:

1) determination of whether current thermal conditions are detrimentally impacting the aquatic community that inhabits the study reach; and

2) determination of whether currently applicable state standard (Secondary Contact and Indigenous Aquatic Life standards modified for the Dresden Pool) is adequate to protect the aquatic community otherwise capable of inhabiting the study reach.

If a negative conclusion results in either instance and if it is found that the implementation of the General Use Standard would cause a substantial and wide spread socio-economic impact, it is recommended that the Agency collaborates with the stakeholders group, particularly Midwest Generation, to devise and propose new thermal standard that would be both environmentally protective and financially and technically attainable.

Through the review presented in this chapter and the underlying data, we concluded the following:

- Ammonium chronic toxicity in water and sediments is increased as a result of temperature. High temperature affects the ammonium toxicity directly by making it more toxic and, by reducing nitrification in the upper sediment layer, it causes more release of ammonium from the sediment.