Annual Report

A Description and Assessment of the Raft River
Lotic System in the Vicinity of the
Raft River Geothermal Area.

Supplement to contract #EY-77-S-07-1674

Submitted to:

Department of Energy
Idaho Operations Office
Idaho Falls, Idaho 83401

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

MASTER

Submitted by:

James R. Barnes and Dennis K. Shiozawa
Department of Zoology
Brigham Young University
Provo, Utah 84602

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Introduction

The development of the Raft River Geothermal facilities by EG&G and the Department of Energy has required the compilation of mitigative information for the surrounding region. The Raft River is the only perennial lotic system within this area and one concern has been the impact a spill of geothermal water would have on the biota of the stream. If such a perturbation will permanently alter the structure or functioning of a unique biotic community, then precautions should be taken to divert geothermal spills away from the stream. Prediction of the impact of such a disturbance is difficult without first establishing the structure of the communities involved and then evaluating their functional components. Identification of the structure of these communities is the baseline information which was the objective of this study. Future investigations should address the functional components and mechanisms associated with the dominant and important structural elements.

Some inventories have been previously conducted on the Raft River. Algae (Clark, 1977), fish (Watson, Cannamela & Neve, 1977), and macro-invertebrates (Speth, 1976) were examined but the resulting reports give little insight into the structure of various sections of the Raft River. The present study was initiated in 1978 to more fully inventory the Raft River communities. In this report we will discuss the results of the inventory in terms of potential recovery of downstream communities from the impact of geothermal water induced perturbations.

Descriptions of the study areas

Three stations were selected on the Raft River (Fig. 1) near the geothermal test site. This region is a cold desert, typical of much of Utah and Idaho. It is subject to hot, dry summers and cold winters. The dominant species of woody vegetation near the stream are sage and rabbit brush. Some small willows grow along portions of the stream bank. The banks are highly eroded and often rise six or more feet vertically from the water surface. In more stable regions of the stream grass, sedges and cattails were noted and moist oxbow serve as important refuges for still water organisms.

The mean monthly discharge (Table 1) for the Raft River in the study area is recorded by the U.S. Geological Survey which has a permanent gauging stations approximately 6 km upstream from the main geothermal facilities. Peak discharge occurs with snow melt. This is usually during April and May. The lowest discharge periods are from July to September. This depression is related to both low summer rainfall and diversion of water for irrigation. Summer storms can raise the water level rapidly however because the xeric surroundings have a low water retention capacity. Conductivity (Table 1) follows a trend inversely proportional to the discharge. This is expected since increased volume of water flowing through the system, especially from surface runoff, would dilute the dissolved solids in transport, thus reducing the concentration of charged ions. The discharge rate of the Raft River accounts for 60% of the observed seasonal variation in conductivity. The lack of a higher predictability is probably related to factors such as the rate of inflow from subterranean sources and irrigation return flow.

The three stations were designated Stations A, B and C. Station A, the downstream site, was located approximately one km southeast and downstream from the main geothermal facilities (at well #2) near a commercial greenhouse. Station B was approximately 0.4 km south of well #2 and Station C was located approximately six km to the southwest of the geothermal site. Station C was the upstream station and would not be affected by geothermal spills.

Station A (Fig. 2) had an annual mean depth of 24.3 cm (Table 2) and the benthic substrate was 56% rubble. Epilithic algae was dominated by colonies of Nostoc (Cyanophyta: Cyanophyceae-Bluegreen algae) during the spring sampling but by summer attached filamentous green algae predominated and remained so for the rest of the growing season. Station B (Fig. 3) had a mean depth of 23.0 cm (Table 2) and the substrate was only 29% rubble with the remaining 71% being gravel or finer. Here epilithic algae consisted of both Nostoc and filamentous algae. The filamentous algae was again dominant in the summer although never in the high density seen at Station A. This is partially related to less rubble being available for algae attachment at site B. Station C (Fig. 4) had a mean depth of 24.5 cm (Table 2) with rubble areas making up 51% of the benthos. Here the algal cover followed the same general trends seen at the other two stations except that filamentous algae never occurred in the extensive mats characteristic of the lower stations. The algae also appeared to be dominated by a different species than were abundant at Stations A and B although no samples were taken for identification or quantification.

Similarity of mean annual depth at Stations A, B and C (Table 2) does not reflect the actual trends. Examination of the individual sampling

dates indicates that Stations A and B have much greater fluctuations than Station C. These two stations were more shallow during the summer and deeper in the winter. The shallowness was associated with a wider stream channel, especially at Station B and the increased winter depth is related to the freezing of the stream. During sampling in November-December 1979 both Stations A and B were completely frozen over. The samples taken required cutting through 30 or more centimeters of ice. In most samples a double layer of ice was found. This double layer consisted of a surface layer of ice, a layer of flowing water, another layer of ice and finally a thin layer of water over the substrate. This layering was caused by the initial freezing of the stream surface, especially those areas over pools and runs, while riffles remained open because of their turbulence. As this layer of ice thickened, the flow of water under it was restricted and water began to flow over the ice from the riffles. This water again froze on its surface resulting in the double layer described above. In some areas the lower layer of ice had frozen completely to the substrate but in most samples we found a 2-5 cm space filled with water. This condition would allow a refuge for benthic invertebrates but it would be selectively detrimental to large fish.

A final characterization of the stations considers the total dissolved solids (Table 3). The level of TDS parallels the conductivity of the Raft River given earlier (Table 1). A more interesting relationship arises when between station comparisons are made. Station C, the upstream station, shows the lowest TDS level. During low flow periods (September) this difference is most noticable. Station A has 2.3 times the TDS of Station C and Station B has 1.8 times the TDS. What appears to be a linear trend is developing. The April 1980 samples do not display this

same magnitude of change but the general trend remains. The overall TDS was higher in April than September at the upstream station.

The higher TDS of Stations A & B were related to the presence of hardpan conditions in the riffle areas of these stations. The rubble of Station A could only be removed with considerable difficulty because of cementing by carbonates precipitating onto the rocks and sediment matrix. Much of this precipitant was associated with the photosynthetic activities of epilithic algae. The net result of this precipitate was a more permanent stream bed over the riffle areas. This condition was obvious after a spring flood in 1980 completely restructured Station C, burying pools, changing stream channels, and moving riffles, while Stations A and B had essentially no effect from the high water flow. The only visible change in Station A were a few narrow strips up to 20 cm wide and 3-5 meters long where the substrate was ripped out by the high rate of flow. No other impact was seen on the riffles.

Methods

Fish

Two methods were used for fish collecting. Initially electrofishing gear using a pulsed DC current from a boat mounted generator was used. This method was satisfactory for dace and sculpins but it was ineffective on reidside shiners (see Table 4) and was selectively lethal to large Utah and mountain suckers. Electrofishing was also hampered by the high turbidity levels of the Raft River, especially after rains and throughout the spring season. Because of these problems, the mode of sampling was changed to seining in July of 1979.

The standard procedure for each station was to first block the upstream and downstream boundaries of a 75 meter section of the stream using seines. This prevented the movement of fish into or out of the section during the census. The section was then seined and all captured fish placed into 30 gallon containers on shore. These specimens were identified to species, measured, weighed, marked with a caudal fin clip and then released in the stream prior to the recapture run. Because of the short time allowed for randomization of the marked fish, the method of analysis was that of Moran & Zippen which is a removal summation technique based on equal sampling effort (Everhart, Zippen & Young, 1975). The fish data was entered into a computer file and a program written to sort the data and calculate densities and catchability of each fish species. Because some recapture data did not fit the assumptions of the Moran & Zippen method, a default decision was inserted to estimate the population using the Peterson method with the appropriate variance estimate. The data were also sorted and processed in a package program, MINTAB for basic statistical information and size frequency histograms.

Benthos

Ten benthic samples were taken per site during each sampling period. These samples were arranged in five transects, separated by 10 meter intervals. At each transect two randomly allocated samples were taken.

The type of sample collected was either a core (area = 17.35 sq cm) or a box sample (area = 330 sq cm). Cores were taken in any substrate where the coring device was operable. Otherwise the box sampler was used. The sediment was removed to a depth of 10 cm and preserved in whirlpacs (cores) or gallon jars (box samples) using concentrated formalin. Rose-bengal stain was added to assist sample sorting.

The samples were returned to the laboratory for processing. In the laboratory the samples were washed in a sluice box with a 35 micron screen used to retain the effluent which contained the organisms and fine sediments. The organisms were sorted under a stereo dissecting scope and placed into vials with 70% alcohol. The numerous organisms, such as chironomids and oligochaetes, were subsampled prior to counting, but the majority of invertebrates were completely censused in each sample. Organisms were identified to genus when possible with the exception of the Chironomidae and Oligochaeta. The sample density and diversity was then determined. Benthic numbers were clustered using Ruzicka's (1958) index of similarity.

Sediments retained by the screen were added to that then remaining in the sluice box and this material was oven dried at 80°C for 72 hours. The dry sediments were removed and allowed to cool to room temperature. Size analysis was based on the Phi scale (Cummins, 1962) (Table 5).

The sediments were screened to remove the more coarse particles (Phi-3 or less) and the finer materials (Phi 4 to -2) were placed in a sediment shaker for 15 minutes. Samples with a volume greater than 250 ml were

divided into 250 ml aliquots which were sorted separately. The sediment size fractions were weighed on a triple beam balance. The resulting weight frequencies were converted to percents for between sample comparison. These data were arranged and clustered. Initially silts were examined but the silt categories were never found to consist of more than 2% of the total sediment weight, so silts were eliminated from the analysis.

Results-Discussion

Fish Communities

Seven species of fish, representing four families, were collected at the sampling stations during this study (Table 6). Of these, two cyprinids, Rhinichthys cataractae (longnosa dace) and Richardsonius balteatus (Redside shiner), and one Catostomid (Pantosteus platyrhynchus, the mountain sucker) were considered abundant. Both the Utah sucker (Catostomidae: Catostomus ardens) and the Plute sculpin (Cottidae: Cottus beldingi) were common and the speckled dace (Cyprinidae: Rhinichthys osculus) and cutthroat trout (Salmonidae: Salmo clarki) were rare.

Catchability, the probability of an individual fish being captured, between electrofishing and seining can be qualitatively compared (Table 4) although the results are confounded with time. Electrofishing was bias against redside shiners and selectively favored the catostomids and cottids. This selective effect was related to the larger size of the suckers (Catostomidae) which makes them more susceptible to electric fields and more visible (Larimore, 1961). The cottids were in the shallow riffle areas where turbidity was minimal. During the November 1978 shocking and subsequent (not reported here) electrofishing attempts in the spring and early summer of 1979, many suckers responded to the electric field with tetany. The net result was a higher mortality among the catostomids than we felt was acceptable. This problem, as well as delays induced by the high turbidity of the Raft River following spring melt and summer showers resulted in our switching to seining as the technique for population estimation. Seining was superior to electrofishing except in riffles where the larger substrate particles often entangled the net and allowed some fish escape. This switching of technique effectively divided our

data on fish communities into two sets. One is the electrofishing information collected in November 1978 at Station C (listed as C1 to C4) and the other is the seining information collected during 1979.

The four sections of Station C sampled in November 1978 were delineated by habitat type (Table 7) as riffle, run or pool. C1 was a riffle area dominated by gravel in a sand matrix. Rubble made up between 12 to 25% of the sediment. The average depth was 23.5 cm and the average width was 2.3 meters. The section was 8.1 meters long. C2 was a pool with a sand bottom. Rubble cover was less than 12%. This station had an average depth of 32 cm, and average width of 3.6 meters and was 9 meters long. C3 was a run with 25-50% rubble cover imbedded in a sand matrix. The mean depth was 25.1 cm with an average width of 3.7 meters. It was 14 meters long. C4 was a large pool 13 meters long with an average width of 4.5 meters. It had a sandy bottom with rubble cover being less than 12%. The mean depth was 33.2 cm.

Cluster analysis of the fish community in these four stations (Figure 6) places Station C2 as being very dissimilar ($r^2 = .053$) to synthetic Stations C1, C3 and C4. This difference was due to the lack of young of the year longnose dace and mountain suckers in C2. C2 had only a 0.035 r^2 value with C4 alone, yet both were pool habitats. C3 and C1 clustered together at $r^2 = .856$ and the resulting synthetic station clustered with C4 ($r^2 = .634$). The high association between C3 and C1 was expected because of the similarity in habitat although the surface area of each (Table 7) was quite different. The difference in similarity value between C2 and C4 from what would have been expected probably related to current speed. The pool at C2 was subject to a linear flow of water from the run above it. There was no appreciable bend in the stream and the current was

relatively swift through the pool. The pool at C4 was at a bend in the channel and the banks acted to slow the current more. This pool was also almost twice as large as the pool at C2. A riffle was at the head of C4 rather than a run as was the case in the C2 pool. A part of the high density of fish found in C4 (Table 8) was probably due to the high standing crop of food organisms maintained by the riffle.

Mean fish length (Table 9) also gives some insight into the different subsections of Station C during November 1978. The longnose dace from C2 are longer than those in Stations C1, C3 and C4, while the mountain sucker and Utah sucker average sizes are similar between the two pool sections. The larger mountain and Utah suckers prefer deeper water areas thus selecting the pools. The longnose dace are more influenced by current speeds, larger fish being in areas of swifter currents. C3 and C4 both had regions of lower current velocity and the smaller dace were found in these areas. This stratification of water depth/current preference may play an important role in the trends seen with the seining studies conducted in 1979. Diversity of the fish communities in the November 1978 study shows the diversity to be lowest in the riffle and highest in the large pool (C4). This relationship is opposite than usually implied for benthic organisms (Hynes 1972) but here potential diel movements need to be considered. The extensive biomass found in pool C4 could not be supported by energy fixed within the pool and could doubtfully be supported by drift import from upstream. A more likely strategy for these fish would be to move out of the pool at night to forage in the more productive shallows, especially the riffle areas. The presence of avian predators in the area would discourage daylight feeding in these shallows. The fish surveys were conducted during the day so the distribution seen represents preferred

refuge areas (note that upstream and downstream movement was blocked using seines) rather than a full diel habitat preference. If this is the case, one would expect diversity to be higher in the better refuge areas. Pools did have the higher diversity values, and are probably better refuges, especially for the larger fish.

Once seines were used for the main sampling technique (July 1979) a picture of the densities of various sections of the Raft River could be formulated. Seining allowed the sampling of all stations without regard to weather conditions. Three surveys were made on the stream in 1979. The first in July, next in September and one in December. In July and September Stations A, B and C were sampled. In December only Station C could be seined since both Stations A and B were frozen over. Examination of the fish densities (Table 11) over time indicates a general population increase between July and September and a definite decrease in December. Much of the change is in the longnose dace populations where it appears (Appendix 2) most of the increase resulted from recruitment of young of the year fish into a more readily captured size class. A more interesting trend occurs in the Redside shiners, Mountain suckers and Utah suckers. These fish show a progressive shift in density (Table 11) distribution between the three stations. This is more apparent if percentages are examined rather than numbers (Table 12). It is important to note that the relative percentages of Piute sculpin and longnose dace do not appreciably change between July and September but a definite decrease in the aforementioned three fish was noted in the downstream station (A) in September. This change implies a migration of these three species. It could be a response to decreasing flow rates in late summer, declining water temperatures in the fall, or increasing size of the fish. The migration appears to be an

upstream one and that would have a definite survival value to the fish if upstream areas remain more open during the winter, especially with the freezing conditions observed during December 1979.

Cluster analysis of the fish communities (Fig. 6) based on correlation coefficients (r^2) separate Station C in November 1978 (electrofishing) as being very dissimilar to all other stations. This supports the discussion of bias induced by the use of electrofishing in this stream. Stations A and B were very similar. All A and B Stations cluster together at the 80% similarity level (Table 13), but none of the C Stations do. This is indicative of a temporal change in the fish community structure at Station C while Stations A and B do not have the same trend. This is consistent with the hypothesis that the fish move upstream in the late summer or early fall. As these fish leave the downstream sections, they leave in proportion to their species and age class densities in the sections, with the exception of the longnose dace and Plute sculpin. This would result in changes in density but not age structure thus the downstream stations would maintain high correlations with themselves over time. Station C however was dominated by larger fish (Table 9) averaging 50% larger (range 17 to 88%) than those in Stations A and B (with the exception of the Plute sculpin). With the upstream movement of small fish the average length of the Station C fish decreased. The result would be similar in the size classes which were used for clustering. The density of the smaller size classes would increase. Thus the similarity of Station C with itself over time would change. The July 1979 Station C was the most dissimilar (excluding C-November 78 from consideration) with the September and December 1979 C Station samples being more intermediate. This implies a slight convergence of Station C towards Stations A and B over time. This result again is consistent with the hypothesis of fish movement.

Benthic Communities

Summaries of the benthic samples are in Appendix 3. In all 210 benthic samples were taken, although one was lost during processing resulting in a total of 209 samples. These samples were evaluated for both sediments and invertebrates. The sediment data will be discussed first.

Cluster analysis of the sediment data was run on the average sediment frequency composition from each station on each date. The resulting dendrogram (Fig. 7) showed three distinct clusters, one consisting of a series of Station B samples, one with a series of spring samples and the third with the remaining A, B and C samples. Seasonality was not apparent although such trends should be expected in streams (DeMarch 1976, Shiozawa, 1978). When the cluster was collapsed to the 65% similarity value (Table 14) a pattern emerged. Station A had all of its sampling dates fall into two clusters. Two in the spring of 1979 and the rest, from the summer 1979 - spring 1980, in the second. Station B had its sampling dates fall into four separate clusters. Station C had its 7 sampling dates fall into 5 separate clusters. From this we can see that Station C had the greatest temporal diversity, followed by Station B. Yet examination of the sediment diversity shows Stations A, B and C to be very similar (Table 15 and Appendix 3) in both diversity and evenness.

A string is defined here as the occurrence of consecutive dates in a given cluster at the set similarity level. It may be as short as one or as long as seven in our study. Station A, with all of its samples falling into one of two clusters, had only two strings. The consecutive dates changed clusters only once. Station B with the dates falling into four clusters had five strings. The differences over time were greater than in

Station A. Station C with five clusters had seven strings (all of one station each). This station showed the most heterogeneity over time. The cause of these differences was discussed in the site description. Stations A and B had carbonate precipitation in the riffles and this cemented and stabilized these areas; little change was expected over time. Station C did not. Therefore Station C would be expected to undergo seasonal changes in sorting (with the spring runoff) and siltation (with decreasing water flow) while the riffle areas of Stations B and C would be permanent in their size composition because of the encrusted surface. Station B was more variable than Station A because less of Station B was cemented riffle. Much of it consisted of a gravel run with a shifting sand matrix.

Algal cover was categorized into one of five percentage classes for each sample (Table 16) over the seven sampling dates. A general seasonal trend occurs with low algal cover in the spring and increasing cover through the summer into September. The increase in percent cover is most rapid on the large particle sizes which were collected in the box sampler. This is related to the higher stability or persistence of rubble material. Algal colonization and growth in core samples lags that of box samples. The cores were taken in gravel or finer substrates and their higher susceptibility to erosion is reflected in the colonization lag. This pattern occurs in all areas although a higher proportion of the samples in Stations B and C show no algal cover during the year. As discussed earlier, Station A is characterized by a hardpan substrate in the riffle and run areas. This hardpan is formed by the activities of a crustose algae which cements the rubble and sediment matrix together. This hardpan not only increases the resistance of the riffle and runs to erosion, but it also increases the area available for the growth of epilithic filamentous

algae. While we do not know the period when the carbonate forming algae is most active, the filamentous algae at Station A became abundant in early summer and remained dominant through September. Station B followed a similar trend but fewer samples obtained high algae densities. This is related to the presence of an extensive sand run in Station B. Many areas within this run were never effectively colonized by algae. Station C shows a seasonal trend similar to that of Station A. The main discrepancy occurs in April 1980 when all of the box samples had over 50% algae cover. This cover was due to a filamentous green algae which was attached to the larger substrate particles. The rapid growth and colonization of algae at this station appears to be a direct consequence of the flood. The disturbance eliminated competing epilithic algae and grazing organisms which normally kept the filamentous green algae out or in low numbers. The rocks were very well scrubbed of benthic invertebrates and little detritus was noted interstitially. Relatively high populations of dace and suckers could be seen in the pool portions of this stream so not all grazing pressure had been eliminated, but most of the established invertebrate grazers were probably gone. Unfortunately this last sample series was taken only for sediment analysis and invertebrate numbers were not evaluated.

Forty-eight invertebrate genera were collected and identified in the course of this study. More genera could be added if the Chironomidae and Oligochaeta were identified to the generic level. For brevity the reader is referred to the general list in Appendix 3. Not all genera occurred in the quantitative samples taken at the three stations. Some were collected during intensive surveys of specialized habitats. Others were present in the stream benthos, but rare and failed to occur in the 10 quantitative samples.

Cluster analysis (Fig. 8) of the benthic communities resulted in only two easily separated clusters, which segregated at approximately 0 similarity. One of the clusters consists of all March and April samples (all stations) while the other consists of the remaining months. Seasonal change in the benthic invertebrate communities were more important than between site differences. When the data are summarized (Table 17) at the 50% similarity level, the number of cluster memberships for Station A is four, B is five, and C is five. The number of strings are respectively five, six and six. Even at the 50% similarity level, the invertebrate communities show little patterning in regards to within-site differences. However, if cluster membership is evaluated for each date, we find that three of the six dates have Stations A, B and C falling into the same cluster and another cluster has 2 of the 3 stations in it. In other words, over half of the clusters segregate by time, regardless of station location.

The invertebrates were also separated into functional groups based on modifications of the designations of Merritt & Cummins (1978). Shredders were relatively rare in all stations except Station C (Table 18). It should also be mentioned that large Tipulids (Tipula = shredder) were collected in the process of seining Station C in December 1979. So they were present although not in high enough frequencies to be collected in the benthic samples. Collectors dominate the systems throughout the year at all stations. They are most abundant during the fall and are in highest densities in Station A and C. Grazers and filter feeders both reach their highest densities in the fall. Because of the sampling interval, it is difficult to define any functional differences between these sections. However, filter feeding density is much higher at Station C than at the other two stations. This could reflect a decrease in the

amount of detritus available downstream. This loss could be due to filter feeders or sedimentation in upstream sections. It appears that fall is the critical time for many of the functions of energy processing, but this is based on organism densities, not on energy flow nor standing crop. A few large grazers may have more of an impact on a system than hundreds of small ones.

Conclusions

This study has enabled the establishing of a brief sketch of the Raft River ecosystem. The physical condition of the stream changes as one proceeds downstream. Part of this change, the dissolved solids component, acts to stabilize the riffle areas in the downstream sections. At the same time, the more shallow gradient of the lower stations renders the stream more subject to freezing during the winter. This in turn creates a much harsher winter environment for fish and invertebrates. The fish population appears to adjust for this problem by moving out of the downstream sections in the late summer and fall. The stimulus for this immigration is not known, but it could be high temperatures in the late summer with low water levels, or low water levels and the fall cooling trends. The size structure of the fish population indicates that for several species the downstream areas act as a nursery ground where the young are not competing with their older cogeners. Whether these fish actively move downstream to spawn or if the young simply drift downstream is not known, but young of the year fish were also collected at Station C. The invertebrate community does not appear to be as strongly location sensitive. Instead seasonal factors are the overriding influences. The invertebrates are most likely keyed to the pulsed nature of detrital input, which is the predominant source of energy in stream systems regardless of its origin (Cummins, 1974, Minshall, 1978, Fisher & Likens, 1973). This would influence all levels of detritivores and the grazers would be reliant upon the growth of algae which is also seasonal.

The potential impact of a geothermal spill, given the present locations of the test wells, appears to be minimal. This assumes the spill would be a single, short lived perturbation. The invertebrate community would

recover through colonization by drifting organisms and while immature fish would be lost, the entire year class would not be eliminated since the young are also found in the upper stations. The unique nature of the stream in the downstream sections appears to be related to physical factors which result in the carbonate precipitation observed at Stations A and B. Yet the invertebrates are more influenced by seasonal factors than the substrate, and the fish utilize the downstream areas as extra habitat for the offspring, but not as a refuge for the population's survival.

References

- Cummins, K. W. 1962 An evaluation of some techniques for the collection and analysis of benthic samples with a special emphasis on lotic waters. *Amer. Midl. Natur.* 67:477-504
- Cummins, K. W. 1974 Structure and function of stream ecosystems. *BioScience* 24:131-641
- _____ & G. Lauff 1969 The influence of substrate particle size on the microdistribution of stream macrobenthos. *Hydrobiologia* 34:145-181
- DeMarch, B. G. E. 1976 Spatial and temporal patterns in macrobenthic species diversity. *J. Fish Res. Board Can.* 33:1261-1270
- Everhart, W. H., A. W. Eipper & W. D. Young 1975 Principles of fishery science. Cornell U. Pr. Ithaca NY 288 pp.
- Fisher, S. G. & G. E. Likens 1973 Energy flow in Bear Brook, New Hampshire: an integrative approach to stream ecosystem metabolism. *Ecol. Monogr.* 43:421-439
- Larimore, R. W. 1961 Fish population and electrofishing success in a warm water stream. *J. Wildlf. Mgt.* 25(1):
- Merritt, R. W. & K. W. Cummins Ed. 1978 An introduction to the aquatic insects of North America. Kendall Hunt Pub. Co. Dubuque, Iowa 441 pp.
- Minshall, G. W. 1978 Autotrophy in stream ecosystems. *Bioscience* 28:767-771
- Ruzicka, M. 1958 Anwendung mathematisch-statistischer methoden in der geobotanik (Synthetische Bearbeitung von anfuaken). *Biologia, Bratisl.* 13:647-661
- Shiozawa, D. K. 1978 The habitat preferences, seasonal drift and abundance of stream microcrustacea. PhD Thesis Univ. of Minn. 151 pp.
- U.S. Geological Survey 1976 Water Resources Data for Idaho Part I Water Data Report ID 76-1
- _____ 1977 Water Resources Data for Idaho Part I. Water Data Report ID 76-1
- _____ 1978 Water Resources Data for Idaho Vol. I. Great Basin and Snake River above King Hill. Water Data Report ID 78-1

Table 1. Raft River discharge and conductivity based on U.S.G.S. Water Data Reports (1976, 1977, 1978).

	<u>Date (Month)</u>											
	<u>Oct.</u>	<u>Nov.</u>	<u>Dec.</u>	<u>Jan.</u>	<u>Feb.</u>	<u>March</u>	<u>April</u>	<u>May</u>	<u>June</u>	<u>July</u>	<u>Aug.</u>	<u>Sept.</u>
Discharge in liters/sec.	334	436	534	512	643	824	1143	1193	610	285	246	246
Conductivity in μ mohs	-	1255	1060	1091	-	965	1005	1018	1145	1260	1300	1200

Table 2. Mean depth at sampling Stations A, B and C on the Raft River.

Date	<u>Station average depth (cm)</u>		
	A	B	C
3-3-79	23.9	21.8	30.0
4-25-79	30.5	34.2	39.5
6-20-79	15.3	16.8	21.2
7-23-79	16.5	14.2	17.7
9-29-79	17.7	13.1	22.5
11-30-79	44.6	33.7	24.0
4-6-80	21.7	26.0	16.8
Annual Average	24.3	23.0	24.5

Table 3. Total dissolved solids at the Raft River sampling stations. (in mg/l)

Station	<u>Date</u>		
	July 1979	Sept. 1979	April 1980
A	—	1.1051	0.7451
B	0.7751	0.8558	0.8080
C	—	0.4743	0.7330

Table 4. Catchability of the fish species in the Raft River, Idaho.

Station	Electrofishing				Seining						
	Date				Date						
	11/78				7/79			9/79			12/79
	C-1	C-2	C-3	C-4	A	B	C	A	B	C	C
Species											
Longnose Dace	.22	---	.17	.38	.57	.38	.11	---	.65	.24	.16
Redside Shiner	---	---	---	---	.88	.68	.68	---	.89	.25	.50
Mountain Sucker	---	.84	.74	.32	.20	.57	.75	.28	.69	---	.17
Utah Sucker	---	---	---	.67	.58	.92	.83	---	---	.65	.33
Plute Sculpin	.60	.89	.00	---	---	---	.70	---	---	---	---
Total	.52	.88	.30	.20	.70	.57	.65	---	.67	---	.19

Table 5. The phi scale for
sediment classification

Phi	Particle Size
-7	128 mm
-6	64 mm
-5	32 mm
-4	16 mm
-3	8 mm
-2	4 mm
-1	2 mm
0	1 mm
1	0.5 mm
2	0.25 mm
3	0.125 mm
4	0.0625 mm

Table 6. List of fish species collected on the Raft River, Idaho
1978-1979.

Family	Species	Common Name	Abundance
Cyprinidae	<u>Rhinichthys cataractae</u>	Longnose dace	Abundant
	<u>Rhinichthys osculus</u>	Speckled dace	Rare
	<u>Richardsonius balteatus</u>	Redside shiner	Abundant
Catostomidae	<u>Pantosteus platyrhynchus</u>	Mountain sucker	Abundant
	<u>Catostomus ardens</u>	Utah sucker	Common
Cottidae	<u>Cottus beldingi</u>	Piute sculpin	Common
Salmonidae	<u>Salmo clarki</u>	Cutthroat trout	Rare

Table 7. Summary of the C substations electrofished in November 1978.

	Stations			
	C1	C2	C3	C4
Habitat	Riffle	Pool	Run	Pool
Substrate Matrix	Sand	Sand	Sand	Sand
Dominant Particle Size	Gravel	Sand	Small Rubble	Sand
% Rubble	12-25%	0-12.5%	25-50%	0-12.5%
% Dominant Particle Size	50+%	25-50%	25-50%	50+%
Mean Depth	23.5 cm	32.0 cm	25.1 cm	33.2 cm
Mean Width	2.3 m	3.6 m	3.7 m	4.5 m
Length	8.1 m	9.0 m	14.0 m	13.0 m
Area	18.6 m ²	32.4 m ²	51.8 m ²	58.5 m ²
Volume	4.4 m ³	10.4 m ³	13.0 m ³	19.4 m ³

Table 8. Density* of fish collected at Station C subsections using electrofishing in November 1978, Raft River, Idaho.

Species	Station			
	C1	C2	C3	C4
Longnose dace	23	2	19	34
Redside shiner	0	1	1	0
Mountain sucker	2	22	10	174
Utah sucker	0	6	0	4
Piute sculpin	28	8	21**	198**
Total	45	39	51	410

* values based on independent species estimates - they will not necessarily sum to the total value.

** estimates based on total fish minus the sum of all other fish except the sculpin.

Table 9. Mean length in centimeters of the fish collected on the Raft River, Idaho.

Station	<u>Date</u>										
	11/78				7/79			9/79			12/79
	C1	C2	C3	C4	A	B	C	A	B	C	C
Species											
Longnose dace	6.7	8.4	5.8	5.8	5.4	5.7	6.8	5.6	5.6	6.9	5.7
Redside shiner	---	---	---	---	6.0	5.8	7.5	5.8	1.6	6.7	6.2
Mountain sucker	16.0	20.7	14.1	20.3	6.4	10.1	17.4	11.0	6.8	14.9	13.4
Utah sucker	---	32.4	---	31.8	7.9	16.2	23.8	---	5.8	11.9	23.2
Piute Sculpin	6.1	6.3	5.7	6.4	---	6.4	6.8	6.3	6.0	6.3	6.3

Table 10. Fish community diversity based on Brillouin's function.

<u>Station</u>	<u>Date</u>	<u>Diversity</u>
C1	Nov. 78	1.04
C2	Nov. 78	1.10
C3	Nov. 78	1.47
C4	Nov. 78	1.62
A	July 79	1.64
B	July 79	1.76
C	July 79	1.91
A	Sept. 79	0.75
B	Sept. 79	1.50
C	Sept. 79	1.81
C	Dec. 79	1.62

Table 11. Density* of fish collected at the Raft River, Idaho stations using seining during 1979.

Species	Station						
	July			September			December
	A	B	C	A	B	C	C
Longnose dace	301	299	261	466	418	385	192
Redside shiner	163	162	266	15	113	264	12
Mountain sucker	25	24	227	5	94	367	217
Utah sucker	21	44	28	0	30	35	9
Piute sculpin	2	8***	14	6	19***	29**	11**
Speckled dace	0	0	0	0	0	2	0
Cutthroat trout	0	0	1	0	0	0	0
Total fish	477	490	751	554	674	1082	441

* values based on independent species estimates - they will not necessarily sum to the total value.

** estimates based on total fish minus the sum of all other fish except the sculpin.

*** estimates based on the total number of fish collected.

Table 12. Percentage of the estimated total densities
for each sampling date at each station.

Species	<u>Date</u>					
	<u>July</u>			<u>September</u>		
	A	B	C	A	B	C
Longnose dace	35	35	30	38	33	29
Redside shiner	26	27	45	4	29	67
Mountain sucker	9	9	82	1	20	79
Utah sucker	23	47	30	0	46	54
Plute sculpin	8	33	59	11	35	54

Table 13. Summary of the fish community cluster at 80% similarity*.

Station	<u>Date</u>			
	Nov. 78	July 79	Sept. 79	Dec. 79
A	—	1	1	—
B	—	1	1	—
C	5	4	2	3

* those stations with the same value are similar at the 80% level.

Table 14. Summary of the sediment cluster at 65% similarity*.

Station	<u>Date</u>							N**	S***
	3/79	4/79	6/79	7/79	9/79	12/79	4/80		
A	6	6	2	2	2	2	2	2	2
B	6	5	1	1	2	1	1	4	5
C	6	5	3	2	4	3	2	5	7

* the stations with the same value are similar at the 65% level.

** N = the number of different clusters (value) groups each station occurred in at the 65% similarity level.

*** S = the number strings (times cluster membership values changed) over time per station.

Table 15. Benthic sediment diversity and evenness.

		<u>Date</u>						
Station		March 79	April 79	June 79	July 79	Sept. 79	Dec. 79	April 80
A	Div.	1.66	1.77	1.57	1.70	1.48	1.56	1.67
	Eye.	.88	.93	.72	.78	.69	.72	.76
B	Div.	1.67	1.71	1.59	1.72	1.49	1.65	1.56
	Eye.	.90	.81	.75	.80	.72	.80	.72
C	Div.	1.80	1.86	1.46	1.59	1.66	1.59	1.60
	Eye.	.88	.86	.66	.72	.77	.72	.74

Table 16. Algal cover class frequencies from three stations on the Raft River, Idaho.

Station	Date	Percent cover*				
		0	+,12.5	12.5-25	25-50	50+
A	March 3, 1979	CCCCCB	BB	BB		
A	April 25, 1979	CCCB	BB	CBB	B	
A	June 20, 1979	CCCB			BBBB	BB
A	July 23, 1979	CC	C	C	CBB	BBB
A	Sept. 29, 1979		C	C	CB	CCCCBB
A	Nov. 30, 1979	CCBB	BB	B	BBB	
A	April 6, 1980	CCCCCB	BBBB			
B	March 3, 1979	CCCCCCCCBBB				
B	April 25, 1979	CCCCCB	C	B		
B	June 20, 1979	CCCCCB			B	BB
B	July 23, 1979	CCC	CCC		BB	B
B	Sept. 29, 1979	CCC	C		CB	CCCC
B	Dec. 1, 1979	CCCCCCCC	B	B		
B	April 6, 1980	CCCCCCCCBB	B			
C	March 3, 1979	CCCCCB	B		BB	
C	April 25, 1979	CCCCB	CB	B		
C	June 20, 1979	CCC	C	C	B	BBBB
C	July 23, 1979	C			CBB	CCBBBB
C	Sept. 29, 1979	CCC				CCBBBB
C	Dec. 1, 1979	CCC	C	CB	B	
C	April 6, 1980	CCC		C		BB

* C = core sample and B = box sample

Table 17. Summary of the benthic invertebrate at 50% similarity*.

Station	<u>Date</u>						N**	S***
	3/79	4/79	6/79	7/79	9/79	12.79		
A	6	7	1	1	4	1	4	5
B	6	8	2	1	3	1	5	6
C	6	9	2	1	5	1	5	6

* those stations with the same value are similar at the 50% level.

** N = the number of different cluster (values) groups each station occurred in at the 50% similarity level.

*** S = the number of strings (times the cluster membership values changed) over time per station.

Table 18. Functional group density in no.'s per 100 sq. cm. for the Raft River invertebrate data.

Station	Functional Group	Total	Date					
			3/79	4/79	6/79	7/79	9/79	12/79
A	Shredder	0.18	0.12	0.00	0.00	0.03	0.00	0.03
	Collector	6183.35	47.73	21.23	768.21	522.70	4356.88	466.60
	Grazer	157.24	4.61	0.15	17.27	23.76	103.62	7.83
	Filterer	314.02	2.26	0.91	0.77	16.50	269.69	23.89
	Piercer	0.55	0.00	0.00	0.00	0.00	0.00	0.55
	Engulfer	15.62	0.06	0.00	0.03	0.09	14.56	0.88
B	Shredder	0.79	0.09	0.12	0.00	0.00	0.59	0.00
	Collector	3810.94	107.39	136.35	798.16	854.26	1372.22	542.56
	Grazer	82.61	2.47	1.22	3.40	6.07	61.74	7.71
	Filterer	87.55	4.18	7.35	0.63	2.57	64.44	8.38
	Piercer	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Engulfer	9.686	1.06	0.00	0.00	4.53	2.156	1.94
C	Shredder	2.37	0.61	0.61	0.00	0.00	1.15	0.00
	Collector	5326.87	73.56	48.46	1187.65	435.71	2907.72	673.77
	Grazer	134.74	3.42	5.89	18.44	6.59	66.01	34.39
	Filterer	926.83	10.62	2.85	7.40	2.42	886.61	16.93
	Piercer	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Engulfer	2.25	0.95	0.12	0.28	0.15	0.12	0.63

Figure 1. Map of the Raft River, Idaho surrounding the Department of Energy Geothermal test area.

Figure 2. Map of Station A, Raft River, Idaho

Figure 3. Map of Station B, Raft River, Idaho

Figure 4. Map of Station C, Raft River, Idaho

Figure 5. Cluster dendrogram of the fish communities in 4 subsections of Station C, November, 1978, Raft River, Idaho.

Figure 6. Cluster dendrogram of the fish communities in the Raft River study sections.

Figure 7. Cluster dendrogram of the sediments from the Raft River study sections.

Figure 8. Cluster dendrogram of the benthic invertebrate communities in the Raft River study sections.