A: Because the navigation release was 30,000 cfs [cubic feet per second]. In the spring I have no idea what flood releases might have been.

Q: There was a lot of speed in that river. But an awful lot of work has been done on those banks on the Missouri because it was so erodible.

A: And because it was so wide and meandering. The channel would be in one location one year and would shift to a different location next year. For navigation, it had to be kept in one place.

Q: Now, when you got there in the early '50's, how much work had they done on the channel stabilization?

A: My guess now would be that most of it had been completed. Don Bondurant from MRD was one of our consultants on the Arkansas, because we were doing the same type of stabilization on the Arkansas River in the late '50's as had been done earlier on the Missouri. The Arkansas was never as wide as the Missouri.

Q: So Bondurant was the MRD man in charge of channel stabilization?

A: Sediment.

Q: So you brought him down and used him with the Arkansas project. Now, who did the Missouri River channel stabilization work?

A: I think that was also Bondurant's responsibility at the division level. I don't know who did it in the districts. At the time I was there, the districts, both Kansas City and Omaha, were building the Agricultural Levee System, the high levees along the river.

Q: Some of which are set back quite far and some of which are right along the river itself?

A: Yes.

***Wendell Johnson***

Q: Was Wendell Johnson still at MRD when you were there?

A: Yes. I don't remember exactly whether we knew that MRD had an opening, but we went to Omaha for an interview in the spring of 1953 and they made us offers. It was at the same grade we had been at WES. They told us later that their personnel people initially wouldn't approve hiring us on the basis that, "No woman was worth that much money," and that Wendell Johnson's reaction was, "We'll show them who runs this office."

Q: So he hired you?

A: Yes.

Q: What was he like?

A: He was a nice person and very competent. The people we worked with in the Corps were by and large some of the finest people I've ever known. This is not to say they couldn't be very testy and demanding when it came to something that wasn't going the way they thought it should go or wasn't done right, and so forth. Wendell Johnson was very effective. He was fair.

***Hydraulics and Hydrology***

Q: You were also there at MRD the time that Tommy Hayes was district engineer for Omaha. Do you remember him at all?

A: I don't remember him. In fact, I don't think I could even tell you who the division engineers were when I was there.

Q: So., at Omaha, you were doing hydraulic work, basically structures, looking at structures, plus the river and channel stabilization and sedimentation. That's a pretty broad scope from structures to sedimentation, isn't it?

A: Well, it was hydraulics. The whole thing was under hydraulics. At that time, Bob Pafford was chief of the planning and reports branch and Tim Waara was head of the water

utilization section in the branch. Our section included hydrology as well as hydraulic structures. We were a fairly small group.

Q: Was it true that most of the districts had those H and H branches well before OCE did?

A: Yes.

Q: They didn't do that until sometime in the '40's and apparently the districts had those branches in the '30's.

A: I'm trying to think. Rock Island had a hydraulics branch in 1942--I think it was just called hydraulics, but it included hydrology.

Q: The Corps definition subsumed hydrology under hydraulics, although the hydrologists disagreed with that.

A: Yes.

Q: Let me ask you a question that goes a little bit beyond this. Did you find that there were any problems between the hydraulic engineers, like yourself, and the hydrologists as that discipline developed its own theoretical underpinnings and desire to be separate?

A: I don't think so. In general, Corps districts usually had very strong people as the branch head of H and H and so I don't really think there was ever any problem like that.There certainly wasn't in Little Rock. By the time I went to Sacramento in 1965, I suppose, is when hydraulics and hydrology were becoming more and more separate. I don't think there was really a problem, but the two were not as closely interrelated as they had been previously. Reservoir regulation became a separate responsibility sometime in the late '50's as more reservoirs were completed and began to operate as a system. MRD established a reservoir operation center while we were there (in about 1954), similar to one set up in the North Pacific Division.

Q: That's what Frank Snyder started doing. In fact, he came back from Europe in 1946 andwas in charge of reservoir regulation.

A: Yes.

Q: He said that was something relatively new in the Corps because it had just started to have some of these big dams. They figured they needed to have a sub-area of responsibility for that.

A: Yes.

Q: Well, that's one of the questions that we have that we're looking at because some of the interviews have been a little testy on, mainly the hydrologists, on their relations with the hydraulics people.

A: Well, it's true that we used to have a lot of arguments. But it usually boiled down to the fact that they really didn't understand what hydraulic engineers were trying to do. Once they understood, then it was fine.

Q: Their work is a lot different than what you were doing.

A: I know, but we used their storms to design the reservoirs, saying, if we did this, what would happen? I don't really think there was controversy in Sacramento, but there were heated discussions. Most of the time I worked in Sacramento, Bill Doyle was head of the planning branch. He began working for the Sacramento District right out of Berkeley, and he worked there until he retired. He knew every river and every dam in the district intimately. In 1965, hydraulic design was in the design branch and hydrology was in the planning branch.

Q: That's a little different, isn't it?

A: Irene was in hydraulic design in the design branch, and I worked as a planner in the planning branch.

Q: Because normally they were both in the same branch with two sections, a hydrology section and a hydraulic design section, if I'm not mistaken.

A: Sacramento always thought that they were different from other Corps districts. Anything east of the Sierras was always referred to as "back east." There had been some reorganization in the Sacramento District shortly after they hired Irene, when they established a hydraulic design section. Up to that time, hydraulic design had been just a part of design branch. But Sacramento was very strong in hydrology because the same people had done the planning and hydrology for many of their big dams.

Q: They also had a lot of water problems there in the delta, too, they dealt with?

A: Yes. I worked on the delta and the navigation channels, as well as delta levees and all of that.

Q: Well, let me go back to MRD. So you worked mostly on the river itself. You didn't really work on the dams, which, basically, were already designed. What were the major things that you did on the river? Were they basically studies of the sedimentation problems, or any replacement structures on the river itself'?

A: We were involved in both studies and in review. One study involved the effect of the dikes on river levels. Another was the dam break study. We were also involved in studies for the closure of Gavins Point Dam. What we were doing in MRD, basically, was reviewing hydraulic work that was done in the districts, Kansas City and Omaha, primarily. We visited the Waterways Experiment Station at Vicksburg to look at the district models, at the solutions, and we reviewed their computations. At that time, the Missouri River Division was not a division that was loved by the districts. Division people were skeptical of some work done in the districts remarking that, "We came out of that district. We know who's left."

Q: So there was a lot of mobility from the districts.

A: Into the division.

Q: Was part of that because of the closing of districts like Fort Peck or Garrison, or that it was a normal migration pattern?

A: I think just a normal pattern.

Q: Was that also one of the problems of having a division office sitting in the same city with a district office?

A: I don't know.

Q: Or maybe there's a lot of promotions out of Omaha to MRD itself?

A: The people in MRD were very competent. They really knew what the districts were doing. They understood the problems. I think in many cases they had been in the district at the time of the feasibility studies or the preliminary design work. Then they were in the division reviewing plans, specifications, and so forth. But there was some resentment by the people in the district. MRD would call them up and say, "Bring your computations and come up and explain them." They'd all known each other for many, many years, and it wasn't a problem that it might have been.

***Little Rock District***

When we transferred to Little Rock in 1955, Little Rock District was beginning their emergency bank stabilization program on the Arkansas River. Irene's work was mostly in hydraulic structures, and I was more in river engineering--sediment, channel work. Working on the Arkansas was the most fun I think I've ever had. We were there from about August of '55 to the spring of '64, during which time I worked initially on bank stabilization, and then we both worked on the locks and dams. During that period, we made many, many trips to the Waterways Experiment Station at Vicksburg because they were running models of our locks and dams. What sort of detail do you want?

Q: We'll get into the details later, as much detail as you want. We're basically interested in anything that you did in those positions, the projects you worked on, the people you worked with, observations on the Corps' strengths, weaknesses, designs. You have a sedimentation background, which is a little different than the people we've talked to, such as Jak Douma, who was basically a structures person.

A: Are you going to talk to Tony Thomas at WES?

Q: I don't know. It depends on what the Office of History wants to do.

A: Tony retired just this past year. Tony worked for me when he was a co-op student in Little Rock and a student at Georgia Tech. We did some sediment computations. I wasn't directly involved in most of the Arkansas River sediment computations, but I was involved in the Little Rock District's sediment models. We had a sediment advisory committee made up of General Whipple, whom you probably [know], and [Hans Albert] "Young Albert" Einstein and Don Bondurant from the Missouri River Division. That was before the Corps had computers so all of the sediment computations were done by hand. It was the sediment computations that Tony was involved in on the Arkansas River that he later at the Corps

Hydraulic Engineering Center (HEC) developed into the HEC 6 Program for sediment transport.

I was looking through the chapter I wrote for A. J. Fredrich in his *Sons of Martha,* and there's a lot in there that might help you with background. (A. J. also worked with us at Little Rock.) The Corps built a lot of projects in the late '40's through the '0'S, locks, dams, storage projects. When I took hydrology from Emory Lane in about 1946, I remember only one hydrology book by Wisler and Brater. There was also one book on water power by H. K. Barrows. But, you know, at that time the hydrologists were all self-made hydrologists. The hydraulic engineers were self-made hydraulic engineers. There were very few college courses in hydrology or hydraulics.

When we worked for the Missouri River Division in 1953-55, MRD had a panel of consultants on river engineering and sediment, including Lorenz Straub of the University of Minnesota, Emory Lane, who had been at Iowa and was then back with the Bureau of Reclamation, Vito Vanoni of Caltech [California Institute of Technology], and Hans Albert Einstein of U.C. Berkeley [University of California, Berkeley]. When Straub returned from two years in Europe in 1929 as a Freeman Fellow studying river engineering and visiting hydraulic laboratories, he worked briefly for the Corps in Kansas City (in the Special Studies Section) on river problems before returning to the University of Minnesota in late 1930. In Kansas City, he had responsibility for sedimentation and hydraulic studies of the Missouri River and its tributaries.

***Section 308 Reports***

Straub's Ph.D. was in structures from Illinois, but in 1930 he received a Professional Engineering degree from Illinois. The title of his thesis was "Sedimentary Characteristics of the Missouri River." I think that the sediment material in the old 308 Report on the Missouri River was largely his work. We used the Missouri River 308 Report in the '50's; and, in fact, we still referenced the 308 report on the Sacramento River in the 1970's. The inventories of water resources, preliminary planning for water resources development, and sediment information contained in those reports was just fantastic. (The 308 Reports were accomplished by the Corps in response to the River and Harbor Act of 1927.)

Q: Those 308 Reports are rather legendary, aren't they?

A: Yes, indeed. They really are. We were in a position to work with all those people, and it was a very inspiring experience. Design of the Arkansas River locks and dams was on the

"cutting edge," to use today's words, because nobody had designed such structures on such sediment-laden rivers before.

Q: The model studies, basically, and the sedimentation?

A: No, the sediment, the structures. Locks and dams had been constructed on the Upper Mississippi and on the Ohio, but those rivers didn't have the sediment worries that we had on the Arkansas. Before construction of large upstream storage reservoirs, the Arkansas had about the same sediment load as the Missouri, but the Missouri doesn't have locks and dams; it is open-river navigation. It was all very interesting. The Little Rock District of the Corps had a field group that gathered much of our basic data--discharge measurements, sediment measurements; we also used a lot of aerial photography. All of us in the hydraulics branch had opportunities to get out and see the river, frequently, to observe what actually happens over time. There was a wonderful spirit of cooperation in the hydraulics branch under Jay Pyle; everybody tried.

In those days, we could hardly consider recreation. But I remember at one of the reservoirs on the Upper Missouri in the early '50's, Gavins Points or Randall (I'm not sure which one it was), one could go out to the old road's end at the water's edge after the reservoir filled. The Corps had provided "minimum facilities for health and safety," and we could get right up to the water's edge of the reservoir. It wasn't until passage of the Federal Water Project Recreation Act in 1965 that opportunities for outdoor recreation and fish and wildlife enhancement were required to be considered in planning for water resource projects. The law also required participation by non-federal bodies, and in the absence of such local participation, facilities for recreation, and fish and wildlife could not be provided. In the '70's after passage of the National Environmental Policy Act (NEPA), many environmentalists took the attitude that, "The Corps should do this, therefore, do it." I don't think they ever really understood that the Corps could do only what they were authorized to do by law. I don't think many people understand that even today.

### *Reasons for Leaving MRD*

Q: But at MRD you were doing the typical division work of reviewing the work of the districts.

A: Yes. Since Irene and I had not done similar detailed studies at the district level, we often felt that while, theoretically, we knew what we were doing, we didn't really have feel for a lot of it. That basically was why we wanted to go to work in a district, why we decided to go to Little Rock.

Q: To go back into the field itself and to do the actual engineering work?

A: Actually, the job in Little Rock was the most fun of all. I was back there two weeks ago and went out and looked at one of the locks and dams. It looks just like it should.

Q: So in '55', you went to Little Rock. What made you leave MRD? Opportunity?

A: Not exactly. First, we really felt that we shouldn't be reviewing things that we didn't know more about. That was the basic thing. Secondly, Omaha was not a place to live in the mid-'50's. You said you lived there three years in the '70'S?

Q: Yes.

A: I've been back to Omaha a number of times, and I think it's probably better now than it was then. They were doing very interesting work. In 1955, we were considering going to work for the State of New York Power Authority on the St. Lawrence Seaway when we found a Department of Agriculture yearbook on climate. We looked at the number of days per year the sun shines in Buffalo and the annual snowfall, and we decided we really didn't want to go there. Little Rock was looking for people at the time, and it seemed like a better place to live.

Q: Yes, I guess it's not too good up there.

A: No, the winters, I think, must be pretty awful.

***Hydraulics Branch***

Q: So you went off to Little Rock, and you were in the hydraulics branch of the engineering division.

A: Yes.

Q: And did you know exactly what they were going to have you do when you went or did that job evolve after you got there?

A: They knew what they were going to have us do. Through ASCE, we knew George Schneider, who was the Chief of the Engineering Division, and we also knew Ed Madden whom we would be working for. They were people we respected and liked.

Q: Now who then headed the hydraulics branch? Was that Pyle?

A: Jay Pyle was the head of that branch. We were not initially in that branch; we were in the planning branch. We worked for Ed Madden, who, I think, is still living in the Dallas area. He was in Little Rock for quite a few years, and then in the Southwestern Division for ten or fifteen years before retiring.

Q: Engineering division or planning?

A: I don't remember which one he was in in SWD.

Q: Was planning part of engineering then or had it been broken up?

A: Yes. This was before they split planning from engineering.

Q: And George Schneider was chief of the engineering in Little Rock then?

A: George Schneider. He's also dead. He was another person with Alzheimers; he wandered off and froze to death before they found him. After he retired, he went to teach at Iowa, and he died after retiring from Iowa.

This is a picture with Colonel Jacoby [shows photograph]. He was probably the nicest, most helpful district engineer I ever worked for.

Q: That was Little Rock?

A: That was Little Rock. I don't think that he was in the Corps very long after his assignment in Little Rock. He went back to Russellville, which is a small town on the Arkansas River just west of Little Rock, where he taught in a small college. He's dead now. He was the soul of tact, consideration; he also knew hydraulics. He participated in our conference with SWD and always defended his people.

Q: Well, that's a DE's job, isn't it?

A: They don't always do it, I think. I found a few other things in my old files. That's what we looked like when we were young [shows photograph].

Q: At the ASCE meetings?

A: Yes, most of these are ASCE meetings. I was the president of the Little Rock Branch in, I think, 1960. So long ago that ASCE has long forgotten they had a woman branch president way back then. There's a lot more stuff of that type. I have a short clipping in here about Gail Hathaway's death, but I don't have the year on it.

***Arkansas River Project***

Q: But the Arkansas Project was underway or was it in the planning stages?

A: Well, the locks and dams were sort of in limbo. We were doing emergency bank stabilization on the whole Arkansas River, revetting reaches where caving banks would eventually ruin the navigation alignment or threatened a levee. That went on until about 1957 when there was funding for construction. That year is probably not exactly right.

Q: But the project had been authorized. Now, there were a lot of bank problems on the Arkansas.

A: Yes. The Arkansas had one stipulation in project authorization that no other Corps bank stabilization project that I know of had and that was that the federal government purchase the land for bank stabilization. In most cases, the local people have to furnish land, easements, and rights-of-way. As a result some of the land acquired for the Arkansas, like where there was a cutoff across a long, looping bend, was later turned over to the Fish and Wildlife Service and made a wildlife refuge. Back in the '50's this was unheard of.

Q: That was Senator Kerr then, wasn't it?

A: Exactly.

Q: And Senator McGee?

A: Right. Primarily Kerr.

Q: Was the problem with the river banks basically the soils there?

A: It's partly the geology. Downstream from Dardanelle there are very few places where there is rock in the banks. It's basically an alluvial river that just meanders and changes course. The other problem is that flows vary greatly. The river essentially dried up in the summer, and I don't remember what the peak flows are, but I would say 600,000 cfs, 700,000 cfs in the 1927 flood. Just tremendously high flows. Now there is this nice stable river always in the same place, with hundreds of recreational boaters as well as commercial traffic. The recreational use that has developed and the parks that have been established--especially in the Little Rock area--are unbelievable in contrast to conditions in the '50's.

Q: In all of the cutoff areas you mean, or all throughout it.

A: The boat launching ramps and so forth are, primarily, right along the main channel in the Little Rock reach.

***River Bank Stabilization Studies***

Q: The: bank stabilization studies were ongoing throughout the Corps of Engineers at that time. Was the Arkansas just one of those areas?

A: Yes, the Corps had been doing bank protection work on the Sacramento and in the southeast. Some of the dikes ("wing dams") along the Upper Mississippi were constructed back in the '20's and '30's.

Q: How did you solve the problem of stabilizing the banks and stabilizing the channel on the Arkansas?

A: Basically the same way it's been done on other alluvial rivers, laying out an alignment that looks like it's what the river would like to do. That is, you determine which bends are generally stable, what the radius is, the width and length of crossings between bends.

I did some consulting for the Vicksburg District in the '80's on the Red River, when they were building locks and dams on the Red. It was very interesting to me that they used the criteria that we developed on the Arkansas for pilot channels, so that the river will develop

the channel, and the old channel can be closed off. We closed off the old bendways so that the old channel would fill in. Vicksburg has generally closed the bendways at the upper end so that the old bendway became a backwater area for fish and wildlife.

Q: So most of the cutoffs on the Arkansas became filled in like they were on the Missouri River?

A: Right.

Q: In some cases the cutoffs on the Arkansas became separate lakes.

A: Yes. I was looking for a picture in *River Engineering* that would show how the cutoffs filled in. There were quite a few cutoffs on the Arkansas. We used a lot of the same designs for the structures (dikes and revetments, closure structures) that were used on the Missouri, or about the same.

Q: When you're studying something like this and you've gained the experience, is it sort of a tendency for you to adopt the same solution, maybe modify it just a little bit, or would you go and look at a completely different solution to the problem?

A: Not only are the rivers different, but every reach of a river is different. It depends on the alignment. It depends on the flow. It depends on what the banks are made of. This picture shows what they're doing in Tucson with the Rillito River you went across this noon. Soil cement .

Q: Soil cement for the bank?

A: They construct it with a grader so that it ends up being about fifteen feet thick along the bank.

Q: Compacted?

A: Semi-compacted, I think. The Lower Mississippi is the only place that I know of where the Corps has done a lot of flexible concrete revetment. It's just too expensive to use that type anywhere else. You can do something that will work as well on smaller rivers, but is cheaper.

Q: That doesn't require all of the construction, you mean?

A: No. If a bend is too sharp, too small a radius for the barge tow to follow along, the concave bank can be moved out to the ends of the spur dikes.After the area between the dikes fills in with sediment, a longitudinal structure may be constructed along the river ends of the dikes and becomes the new bank line.

Q: This is on page 168 of *River Engineering.* Okay. So a lot of your time then was spent in studies of the river?

A: Yes.

Q: Analysis of data, and the banks themselves?

A: With surveys and with aerial mosaics after every flood, and so forth. The actual design of these structures was done in a section in design branch.

Q: Structures?

A: Yes. But it was basic criteria, and we always reviewed designs in hydraulics.

Q: Now, you develop all of the solutions, but would you model them all?

A: No.

Q: In most cases, then, you assumed you wouldn't have a problem?

A: The only locations that were modeled were in the vicinity of a lock and dam, where we wanted to be sure that the currents either didn't go across the channel and adversely affect tows that were entering or leaving the lock or areas downstream of the navigation lock and dam where navigation depths might be marginally adequate. Flow downstream of the spillway is confined, except at very high flows, and the cross section widens out downstream of the lock. Where it widens velocities decrease and sediment tends to deposit. There are various things that can be done to improve sediment transfer in such locations. That's the kind1 of thing that would be modeled.

Q: Keep the sediment in the channel?

A: Right.

Q: So your objective, mostly, is to keep the sediment moving.

A: Right.

***Dams***

Q: And to keep increasing the speed of the flow?

A: Navigation dams are very low structures. The spillway sill is almost on the river bed. When the spillway gates are fully open, then the dam is a very small obstruction so whatever sediment comes in the upper pool, hopefully, goes through. It doesn't quite work like that, but that is the objective.

Q: They're a totally different creature from a high dam.

A: From a high dam, yes. I understand that on the Upper Mississippi where navigation pools are about thirty miles or so long, essentially the whole pool has filled with sediment and there is now a relatively narrow channel at normal pool level that navigation follows. I think they have been trying to flush some of sediment through the pools, but I really don't know what's going on at this time.

Q: Yes, because some of those dams go back a number of years.

A: Yes, back to the '30's.

Q: The main ones on the nine-foot channel, I think, are the '30's.

A: Yes.

Q: So what kind of problems do you face--you're talking about silting in. There's a point in tirne where these things are going to silt in almost completely..

A: That's like the big dams. We used to talk about providing sufficient sediment storage capacity for the project life, 100 years. Some of the dams are now getting to be 70-80 years old, and some of the reservoirs are filling in, mostly the smaller dams. They are not Corps dams. I don't know of any moderate to high Corps dam, although there may be some, where they have gone in and excavated out sediment deposits to restore reservoir storage capacity. There are a number of small structures constructed by irrigation districts or utility companies where the reservoirs were small and have filled in and they have removed the sediment.

Sediment deposition in reservoirs is a serious problem in China, worse than ours. PG&E [Pacific Gas & Electric] in California has had this problem. The most critical part of the problem is what to do with the sediment that has been removed because it can't just be dumped downstream. That's not acceptable, environmentally.

Q: Doesn't the sediment have a lot of heavy minerals in it?

A: Not necessarily. It depends on industrial activities in the upstream basin. Mountain streams generally carry only naturally occurring minerals, except in California where there's often mercury from gold mining in the 1850's.

Q: There's a lot of debris in the Sacramento District. ..

A: There was a lot of debris from the mining. The Lower American River is good sized cobbles, from the gold mining. Most of that material in the channels has moved down the rivers and is now deposited in Suisun Bay. The overbanks are still cobbles.

Q: But it's been, basically, washed down.

A: Yes, that's over a hundred years.

Q: It takes a while. What was the basic problem with the sedimentation in the Arkansas? Basically, that you didn't want to fill the navigation channel?

A: Well, the basic problem was how to pass the sediment through the system and down to the Mississippi.

Q: Right. So a matter of keeping it moving then?

A: Yes, because there was so much sediment that if it had deposited, it would have been impossible to keep the navigation channel clean. Now, there are a couple of thdams on the Arkansas that are higher. Dardanelles is higher, and Ozark is higher. They've had some problems with deposition in those reservoirs. At the head of the Dardanelle Reservoir, it has silted in to such a point that the Corps has put in additional spur dikes to maintain navigable depths through the upper end of the reservoir. It's up at the head of the pool, just below the next upstream dam, that the depth problem occurs. Once tows get down farther into the reservoir, sediment deposition doesn't affect navigation.

Q: As you move farther into the pool?

A: Yes. However, if the reservoir is used for storage, flood control storage, storage for water supply, etc., you really want to have all of that storage volume available forever.

Q: So that's where sediment presents another problem, too, because it begins to limit the amount of water that you're going to store?

A: Yes. If it's a multi-purpose reservoir, then there may be so many thousand acre-feet of space allocated to flood control, so many allocated to power, so many for recreation, and so forth. When deposition occurs at the head of a reservoir, which storage are you losing? When deposition becomes sufficiently extensive, it becomes necessary to reallocate the storage space. That's a very controversial thing.

Q: When you get to something like that, who makes those decision?

A: I don't know that any have been made yet.

Q: Who would make those decisions? Would that be the reservoir management people?

A: This would be between agencies, between various interests.

Q: Multiple agency or inter-agency decisions?

A: Yes.

Q: Which are the toughest kind, right?

A: When it involves multiple agencies, yes.

Q: ***So*** the multi-purpose reservoirs are the ones that present the largest problems?

A: At the same time they're the biggest reservoirs so they will be the last to have the problem. It's the small reservoirs for flood control, water supply, or power that are facing the problem now.

***Vane Dikes as an Innovative Approach***

Q: Well, let me go back and ask you about the Arkansas. Were there any innovative approaches that you adopted in the Little Rock District to solve some of these channel stabilization and bank stabilization problems?

A: One thing we did was to try low sills angled to the flow that are vane dikes. They do not extend up through the water surface. They're simply there to keep the channel open in the crossings between the deep part of the channel on the outside of successive bends. These low vanes kept velocities sufficiently high to move the sediment through the system.

Q: So basically they are just like deflectors to continue to deflect the. . .

A: Yes.

Q: Would somebody have recommended these in the process of design? How often were they a new solution to the problem?

A: The low vane dikes are something that I found the French had looked at. They had proposed vane dikes for the Niger. There's a wonderful Dutch report on the Niger and Benue Rivers (1959), and Rousselot and Chabert also reported on studies of vane dikes at a PIANC congress in 196 1. As far as I know? such dikes were not constructed on the Niger. It was an idea, and we model tested vane dikes, and they seemed to work.

Q: So this is another technology transfer? You would have done a lot of research.

A: Yes. This was after I felt I had to learn to read French, when I could read French.

Q: So you were doing this research in French-language sources?

A: Yes.

Q: Now, your American colleagues who couldn't use French would have been in big trouble, because it would have been impossible to find this kind of information.

A: Not exactly, because the Dutch book is in English. But the original stuff--well, Rousselot's may be in English, too. I don't remember that. But, you know, you really have to keep up with what everybody is doing. Rousselot's work came out of PIANC, but I had already seen vane dikes in the Dutch NEDECO report.

Q: So this is a case where that idea struck you as a solution to one of the problems you faced?

A: Yes.

Q: Then you would go ahead and propose that WES test this for you and see what the results would be?

A: Yes.

Q: Now, how long would that process take as far as timewise for you?

A: Maybe a year and a half. We had construction money for the locks and dams. This work was not part of the stabilization program; it was part of the lock and dam program.We had construction money and we could budget for such model tests. In those days, model studies were not that expensive. I think that those tests cost in the order of $70,000, probably.

Q: You had plenty of time before construction to get that done?

A: To try it, yes, because constructing the locks and dams was, I don't remember exactly, about three years in the future, and maybe five for some.

Q: So you had to have your channel ready to go by the time the dams were constructed?

A: The plan was that the bank stabilization program would be constructed first, so that the channel would largely be realigned and would have had time to develop the depths we needed by the time the locks and dams were completed.

***White River Reach***

Q: For the channel. For the locks and dams.

A: They have had a serious problem on the lower part of the project in the White River reach. Have you talked to people in Little Rock?

Q: **No.**

A: The Arkansas navigation project goes down the Arkansas River to Lock and Dam 2. Just above Dam 2 there's a navigation canal that goes over to the White River. The White flows into the Mississippi about ten miles downstream of the canal. The White had long been a very stable river with very low sediment transport.

The Mississippi in the vicinity of the White River, and I don't know why, has been degrading in the last twenty years. As it has degraded, the bed of the lower White River in the navigation reach has also been going down. The tail-water in the White below Lock 1 is so low now that tows have trouble navigating to the Mississippi. This is about a ten-mile reach. I understand that a lock and dam has been authorized for construction near the mouth of the White to provide adequate depth in that reach of the project. This is something we did not envision in designing the project forty years ago.

Q: What's the cause of that? Lack of flow through the...

A: It has to do with whatever is happening in the Mississippi. This is a long-term thing. It may be related to the influence of themajor storage dams on the Upper Missouri River that have trapped a lot of the sediment load that formerly was transported into the Lower Mississippi. I don't know what LMVD [Lower Mississippi Valley Division] is doing in way of studies or what Little Rock has done, so it would be speculation on why the Mississippi is lowering.

Q: So what you're having here is the equivalent of erosion. You're not having any depositing.

A: It's bed erosion. As the bed of the Mississippi degrades at the mouth of the White, degradation works back up the White River.

Q: Solve one problem and you find another one.

A: Yes, but it took thirty years for it to get that bad.

Q: Your vane dikes are certainly an example of a successful idea.

A: Yes, as far as I know.

Q: How about other ones that might not have succeeded? What solutions did you try that did not work or maybe did not model test properly and were not adopted? Or you did adopt and it didn't succeed in solving the problem you faced?

A: We didn't anticipate the problem of degradation of the White River; our foresight just wasn't good enough. If, in fact, lowering of the Mississippi is due to the reduced sediment load coming in primarily from the Missouri, then it's something that we perhaps should have expected. However, it is not something that could have been physically modeled, and it was probably beyond our ability to compute at that time.

Our computations of channel width were not always precise, and some reaches have required extension of spur dikes to narrow the river to provide a stable channel of sufficient depth for navigation.

Q: This brings up a question. Do you know Brien Winkley?

A: Yes.

Q: Well, I was just going to ask you. He makes a contention the Corps really doesn't understand rivers.

A: I don't know what his problem is with the Corps. He is highly critical.

Q: He just has his own ideas.

A: Yes. And, of course, there's a professor at LSU, I think it is, who insists that the Corps is going to lose the Old River Control Structure. Do you know about him?

Q: Did you ever do any work on that?

A: No, not really. The only reason I'm at all familiar with the Old River Control Structure is that when I was working on the Red River in the'80's I had a chance to see it. I knew about the control structure from having worked in Mississippi before, and I did see the models at WES at Vicksburg.

Q: But some people argue that if the river wants to go that way, it's going to go that way, sooner or later.

A: Well, that's what the man at LSU thinks.

Q: I think some people in the Corps think that, too, from what I've heard.

A: It could be. Have you talked to people in the Vicksburg District?

Q: No, I haven't. I know someone who has talked to most of those folks down there in LMVD and New Orleans District.

A: Brien Winkley and Stanley Schumm have edited a book that ASCE published on large alluvial rivers. It's really a descriptive book. I haven't had a chance to read the whole thing. Schumm has done a lot of consulting for the Vicksburg District.

Q: Winkley worked for WES or Vicksburg District?

A: I think he worked for the Vicksburg District. I don't think he worked for the Commission.

***Pile Dikes on the Arkansas System***

Q: Is there anything else about the Arkansas system that you particularly remember?

A: With regard to the systems of pile dikes, we wanted the sediment to be deposited in the dike systems. In the early '60's, Dow Chemical had a flocculent that they were convinced would cause fine sediments to collect infloes and deposit. This goes back to something that didn't work, I guess. We tried it. Dow provided the material. Our field crew did it. We surveyed the site before and after applying the flocculent to see if it increased the rate at which deposition occurred in the dike fields. It really was not effective.

Q: So that was an idea that you tried, and it just didn't work?

A: Yes.

Q: Are there any structures that you tried to use that were less than effective?

A: Pile dikes deteriorate with age, and they usually end up being essentially stone fill structures, eventually. It's cheaper to wait for some deposition in the dike fields and then add stone on top of that fill than it is to build a stone fill structure, initially. So most of what started out as pile dikes are stone fill dikes. This is true on the Missouri, too, I think.

Q: So how long would it take for them to fill to a certain point where you could then put the stone on?

A: It varies depending on the particular site on the river and with the sequence of flows. Twenty to thirty years, probably, in general.

Q: So, eventually, those piles will all rot away, and you'll basically have a stone dike.

A: Yes.

Q: And they're going to stay in place usually, right?

A: Yes, until a flood moves them.

Q: A big flood. So you stayed in Little Rock until, in that first job until '61?

A: '60.

Q: And then you stayed until '64? We just talked about your whole time in Little Rock.

A: Yes.

Q: Is there anything else in the Little Rock years that you can remember? A particular significant experience?

A: Not that I can think of off-hand.

Q: You wrote a major report on the channel stabilization program on the Arkansas that WES or someone else published?

A: Yes. The 1963 ASCE paper was on the Arkansas River cutoffs. A lot of the material on cutoffs in *River Engineering* is from that paper. That paper was translated into French and republished by PIANC also.

Q: You wrote those papers basically to pass on the experience that you had there?

A: Well, it was to share with others what we were doing. There was much interest in bank stabilization at that time. Several Corps Districts were doing a lot of bank protection work--on the Missouri, Rio Grande, Savannah, Apalachicola, and Columbia Rivers. There was a committee in the Waterways and Harbors Division of ASCE on bank stabilization. I was on that committee for a long time, ten, twelve years, or so.

***Arkansas River Cutoffs***

Q: Were you involved in that Corps of Engineers' Bank Stabilization Committee, the one that Jake Douma was involved with?

A: When I was in Little Rock, yes. The same ASCE paper was published in one of the reports on bank stabilization.

Q: ***So*** it was ASCE and WES.

A: It was ASCE, PIANC, and WES, all three. We found some things on the Arkansas River cutoffs that were unexpected. When you excavate a cutoff, the river is shortened and the bed slope is steepened through the cutoff. The short, steeper reach has greater sediment transport capacity, and the bed slope adjusts. It was expected that the channel upstream of cutoffs would degrade as the slope adjusted. Our data indicated that the cutoffs had little effect at that time (1963) on lowering the stage-discharge relationships or modifying the riverbed immediately upstream or downstream of the cutoffs. The sharper the bend, the shorter the cutoff, and we speak of the ratio of the old bend length to the cutoff length. The shorter the cutoff is compared to the old bend length, the larger the length ratio is, and the more degradation. You would expect to have degradation at the head end of the cutoff, and we just didn't get it. We had some cutoffs that had been in place for some twenty years at that time.

Q: Was that an unusual result?

A: Yes, it was different from what we expected to find and different from what they thought had occurred on the Missouri.

Q: How about the Mississippi with its cutoffs. Did they show the same results as the Missouri?

A: I really don't know about that. I think, in general, the Mississippi cutoffs, except for a couple, are not of the same type.

Q: Because they don't like to stay where they are?

A: That's right. The river's flowing downstream and the bank on the outer (concave) side of the bend will erode. Bank erosion usually occurs along the downstream part of the bend.

Q: And they deposit on the. . .

A: On the inside. The sediment eroded on the concave bank, generally, deposits in the next bend downstream, yes. There is a lot of sediment movement along the channel, but it isn't the same particle of sediment that moves all the way through.

***Dardanelle Dam***

Q: ***So*** by the time you left Little Rock you were a sedimentation expert?

A: No.

Q: No?

A: I knew a little bit about rivers, but I was no sedimentation expert. I guess I knew more about the interaction between sediment, the channel, and the banks, but not so much about the actual mechanics of sediment transport.

Q: Well, there are very few people who are in--I mean sedimentation transport is not an everyday skill in the area of civil engineering.

A: No, and there are more people dabbling in it today than there used to be.

Q: Today?

A: One of the things we looked at at Dardanelle, which is somewhat higher than the other navigation dams, was releasing what we call "clear water." Clear water releases from a reservoir carry some sediment, but most of the sediment load entering a large reservoir is deposited in the reservoir and the water released downstream is relatively clear. We knew that the clear water in the channel below Dardanelle Dam would be picking up material from the bed immediately below the dam initially and then farther and farther downstream as time progressed, as well as eroding the banks, so that the turbines were not set at the present river bed. We worked with an estimated future degraded bed. The sediment on the Arkansas isn't uniform. It consists of a range of sizes of material. So as the bed degrades, the larger, heavier bed material doesn't move, and finally, the bed becomes armored. The problem was to estimate where the bed would be, at what elevation, when the normal release velocities would be insufficient to move the armor material.

This is a problem that has become more recognized since our work on the Arkansas in the '60's. On the Missouri River the same thing was done, but the Missouri below Gavins Point Dam armored at a much higher elevation than they expected. Consequently, power generation was less than they expected. This was due to a local gravel deposit that had been missed when they sampled the bed material. They excavated that layer of material and then they got additional degradation down to the level they had designed for.

Q: A lot of this is basically guess work, then?

A: Yes, in that there are always unknowns.

Q: Using your formula, knowledge, and figuring out this is going to happen, which it doesn't necessarily always happen that way.

A: That is what Straub used to say, "Hydraulics is more an art than a science." Of course, it's what today's generation wants to put into equations and into the computer. I have reservations.

Q: Computers can help you, but they can't do all of that.

A: They really can't--I think the biggest problem with computers today is that so many people don't write the programs they use. They learn to use the programs, and they really don't recognize all the approximations that go into them.

Q: So they adopt the school solution with the computer. Push a button, and you've got an answer.

A: Yes.

Q: Whereas, you didn't do that.

A: Work on the Arkansas predated computers. You can use the computer and get a very wrong answer.

Q: It goes back to that axiom about "garbage in, garbage out."

A: Yes.

***Computers in the Corps of Engineers***

Q: From your experience, when did computers really begin to come into the Corps?

A: We got the first computer in MRD while Irene and I were in Omaha in about '54. It was used for reservoir routing for three-month projections of reservoir operation, primarily to

optimize the power generation while meeting requirements for flood control space and minimum flows for navigation during the navigation season. That computer occupied a space half as large as this room; it was huge. In Little Rock we didn't get a computer until about '62, maybe '63. We didn't have it to use on the sediment studies while I was there. They did use it after I left.

Q: So it would have made a lot of difference for you?

A: It would have made the computations a lot less tedious, yes. I was not involved in the details of it, but the sediment transport computations were very tedious.

Q: One of the things that Vern Hagen said was that the computers allowed the engineers to get away from spending a lot of time on tedious hand calculations and really devote themselves to some major thinking about projects, and ideas, and designs, and get away from all of the slide-rule type of-things. I guess there were mountains of calculations of these things.

A: Oh, yes. It's unbelievable, pages, and pages, and pages. And, of course, it not only had to be done, it had to be checked.

Q: So if you had somebody working with you on this, you had to recheck what they did?

A: Somebody had to.

***Waterways Experiment Station in Vicksburg***

Q: Well, let me take you back then to where we left off, which was when you were in Little Rock working on the Arkansas.

A: From Little Rock, I went to Vicksburg in the spring of 1964 to work at the Waterways Experiment Station in the wave dynamics section for Bob Hudson. In the earl '60's in Little Rock, we were working on feasibility studies for several of its locks and dams on the Arkansas River, and preparing contract plans and specifications on others. We had many different projects somewhere underway and there was a lot going on. When I went to Vicksburg, there was nothing that was urgent and I soon found that I really wasn't very happy to be back in the laboratory. One of the highlights of working at WES at that time was working with Garbis Keulegan, who was a very remarkable person. He was about 75 at that time and had become a special consultant to WES in 1960 after he retired from the Bureau

of Standards. Dr. Keulegan continued to work actively until 1988 when he retired at age 98. He died in 1989.

Q: But you didn't stay very long?

A: No. I was there from--I don't remember exactly when I went, but it was from about April to November. I was chief of the wave dynamics section of the water waves branch headed by Bob Hudson in the WES hydraulics laboratory. Fortson was still head of the hydraulics lab at that time, and Fred Brown was technical director of WES. We were not very busy compared to the Little Rock District. I couldn't find enough to keep myself busy.

Q: In Little Rock?

A: No, at WES, in that particular job. Waves were a different area from what I had been working in, and I felt I was doing something I didn't know enough about, and I just felt it was not a good situation.

Q: In the hydraulics lab there?

A: Yes.

***Sacramento District***

Q: So it was a good time to leave?

A: Yes. If it was going to happen, that was a good time.

This is [refers to photograph] from the Sacramento District when Bill Doyle retired. You might like to talk to him and Amalio Gomez. Gomez was Chief of the Engineering Division when I went to Sacramento. When I went out there, HEC was still a part of the Sacramento District. At the time I went to Sacramento, there were about five people in the District who were in the same graduating class at the University of California, Berkeley. I think three of them went on to become Chief of the Engineering Division.

Q: Gomez only recently retired, didn't he?

A: No. Gomez retired in about 1974, before I did. Geandrot followed Gomez, then George Weddell. Dick Vasquez was the last one who retired, and I think Lou Whitney is the Chief of the Engineering Division there now. Doyle was a civil engineer and a self-made hydrologist. He knew more about hydrology of the Sacramento-San Joaquin Basin than the people who were doing the hydrology for us.

Q: Well, that's true of a lot of people. A lot of what your Bachelors Degree is in doesn't make any difference.

A: Right. It's what you learn while you're doing it.

Q: Frank Snyder, for example, was straight civil engineering, and he never did civil engineering at all in any of his career. He was all in hydrology and hydraulics.

A: There really isn't a lot of hydraulics in the normal four-year C.E. program. Even here at Arizona, we don't offer very much.

Q: So you rejoined Irene in Sacramento?

A: Irene had transferred to the Sacramento District of the Corps in the spring of 1964, shortly after I had gone to Vicksburg. At that point, we had lived together for about 20 years. Also, I found that Vicksburg at that time was not really a great place to live for a single person. It was depressing. I lived in what was the best apartment building in town at that time. I got an option on a lot and had plans drawn to build a house. Finally, I decided I just didn't want to stay there.

So I also transferred to Sacramento to the planning branch. They hired me primarily for my experience with navigation. I worked on the deep-draft San Francisco Bay to Stockton Project, the Sacramento River Shallow Draft Project, the Sacramento-San Joaquin Delta, local flood protection projects, and large multiple-purpose dams such as Marysville.

The last big project I worked on was the Marysville Lake multiple-purpose dam and reservoir which was not built. At that time, Marysville was about a billion dollar project because it included a large pumpback storage power component. It was probably the first project the Corps had ever estimated at a billion dollars. The State of California had finished construction of Oroville Dam, and the California Department of Water Resources had a large design and construction group headed by H.G. Dewey, who was head of the Mississippi Basin Model Branch in Jackson when we were there. The state wanted to construct

Marysville as a state project with the federal government paying for the flood control function, as had been done at Oroville Dam. The state maintained that they really didn't need the water, and the local cooperation just wasn't there. The Corps has reexamined Marysville again, but it has not been constructed.

Q: What made you decide you were unhappy at WES? Irene had gone to Sacramento already?

A: Yes. Well, at the ASCE Hydraulics Conference in August of 1964, I met the assistant chief of the engineering division.

Q: In Sacramento?

A: In Sacramento. I talked to him about what they were doing and asked if they had any openings. They did, and so then I transferred to Sacramento. I was in planning in Sacramento. While I had worked in a planning branch before, it was always in a hydraulics section. I had never been in a planning branch as a planner before. The basic planning problems related to hydraulics, and it really wasn't all that different, except it involved economics. Later it also involved social and environmental effects.

Q: So your entire career prior to Sacramento was in the engineering division or some branch of engineering, except for WES.

A: Yes. I was in hydraulic design for the most part. Planning at that time was still a branch in the engineering division. In fact, in Sacramento, the planning branch was in the engineering division until about five, eight years ago.

Q: So it was just a directorate or a division?

A: Planning was just a branch of the engineering division.

Q: But separate from the structures hydraulics?

A: In the Little Rock District, hydraulics design was in the hydraulics branch in the engineering division. In Sacramento District, hydraulic design was also in the design branch, but they didn't have a formal hydraulic design section until '64. Prior to that, hydraulic design was clone by a couple of people who worked on hydraulics in the design branch.

Q: Now, why would that be since they had so many projects out there and they had enough rivers?

A: Well, I think, the strength was in the planning branch, and hydrology was in the planning branch. I suppose it was the feeling that if you know the hydrology, what your flow is, anybody can design a structure to pass it.

Q: That was the feeling, but that's not the truth, is it?

A: Well, some of the designs probably weren't the optimum, but they seemed to be adequate. The big problem in the last twenty years has been that spillway design floods are now different (larger) based on more years of record, and many spillways won't pass the larger flows safely. But that's because of new data and better hydrology.

Q: Well, wasn't that also a change in the way the Corps goes about things?

A: Yes, that's true. If you have only ten years of data and you need average annual values fifty , years will give a much better estimate.

Q: So you went into the planning branch in Sacramento.

A: Yes.

***Sacramento River Shallow Draft Navigation Project***

Q: What did they have you do?

A: Initially, I worked on two projects, the Morrison Creek Stream Group Project and a navigation project. The one they really hired me for was the Sacramento River Shallow Draft Navigation Project. The investigation concerned improving the commercial navigation channel upstream from Sacramento to the Feather River, and then up the Feather River. This was in the '60's. There wasn't enough present or projected traffic to justify it, and the investigation ended with the feasibility studies.

At about that time, commercial barge traffic that had been coming up the Sacramento decreased markedly. Traffic was largely petroleum products and rice, and petroleum barges

were replaced by pipelines. There is a thirty-foot deep water ship channel to Sacramento so that ocean-going ships pass through the San Francisco Bay and all of the way up to the Port of Sacramento. Export shipments came to the port by truck or train and went into the ocean-going ships in Sacramento. There was a shallow-draft lock between the deepwater ship channel and the Sacramento River at Sacramento that was designed to handle shallow draft traffic. By the late 1960's there was so little barge traffic that the lock was used, primarily, for recreational navigation. I think it has since been turned over to local agencies for operation as a recreation facility.

Q: So all you had going up there was the ocean-going ships?

A: The big ships, yes. Part of the problem with changing use is related to the time delay between when a feasibility study is completed, when the project is authorized, and when it's constructed. At the time the feasibility studies were done, there was a lot of shallow-draft traffic on the Sacramento River, but by the time the lock was finished, shortly before I went there in 1964, shallow-draft barge traffic had decreased. The Deep Water Ship Channel project was authorized in 1946, and construction was initiated in 1949, suspended in 1950, resumed in 1956, and became operational in June, 1963.

I don't really know what the Corps policy used to be in terms of post-authorization studies, but in general the feasibility studies are reanalyzed in the light of conditions at the time it was authorized. If conditions have changed, a different decision can be made. There can also be a long delay between funding for post-authorization planning and when funds are allocated to start construction. Again, things can change a lot in the interim.

Q: Well, these projects have such long life spans. I mean the life span of some of those projects is 40-50 years, from the time they first start talking about some of them, until they get them in the ground.

A: Yes. It's too bad, because they're needed when you study them and things change. If the project had been constructed shortly after studies were completed, then, perhaps, the change would have been in a different way.

Q: So you said it changed very much for you when you went into planning because you began to have other major concerns, other aspects beyond rivers and hydraulic structures.

A: Yes.

Q: Was that a big change for you, or was it something you had been working with a little bit already?

A: We (the hydraulics branch) were responsible for many design memos [design memorandums] on the Arkansas and the dams included some economics. Certainly, I worked a lot with costs, less with benefits. But the economics section in Sacramento was in the planning branch and they were directly responsible for the detailed economic studies.

Q: So you had worked very closely with them on your **...**

A: Yes.

***Morrison Creek Stream Group Study***

Q: Now, when this work that you were doing on the Sacramento didn't go through, what did you move on to?

A: In the meantime, I was also working on the Morrison Creek Stream Group study in the Sacramento area. This is the other study I started soon after I went to Sacramento. The City of Sacramento is leveed all along the American River and along the Sacramento River, and the area south of the American River is drained by two systems of small streams. The streams originate in the foothills and at the toe of the Sierras and drain out through borrow pits and small lakes along a railroad running along the east bank of the Sacramento River, and eventually into the Sacramento-San Joaquin Delta. This was a local flood protection study.

About the time we finished initial studies of the Morrison Creek basin, at the end of 1969, NEPA was passed. Sacramento County had a plan for urban development in the lower basin, and conservationists were strongly opposed to such development. I'm not sure what has happened in recent years. The project was authorized for construction in about 1976, but I don't know if or when construction funds were allocated for it. In the meantime, Sacramento County constructed segments of the project, based on the Corps' plan, as the basin became urbanized. The original plan included a small flood control reservoir, but the reservoir was not constructed, and the area is all urban now. The county required developers in the basin to make a contribution for infrastructure, including drainage. The county acquired one large track of land in the lower basin, in the Beach-Stone Lakes area for a county park.

### *San Francisco Bay to Stockton Project and Sacramento-San Joaquin Delta Studies*

About that time, I was assigned the San Francisco Bay to Stockton Project which involved deepening the deep-draft navigation project through Suisuin Bay and the lower San Joaquin River to the Port of Stockton. Morrison Creek and the Sacramento River shallow-draft projects were both feasibility studies. San Francisco Bay to Stockton was an authorized project. The studies were post-authorization planning for deepwater (ocean-going) navigation. Later I was assigned the Sacramento-San Joaquin Delta studies which investigated increasing the degree of flood protection for the many islands protected by unstable levees? and increasing public recreation opportunities.

### *Phase II of Sacramento River Bank Protection Project*

I was also responsible for studies for Phase II of the Sacramento River Bank Protection Project, including investigating the need for mitigation lands to compensate for environmental losses. A separate study was made to assess potential for including the Sacramento River from Sacramento upstream to Shasta Dam in the Wild and Scenic River System.

### *Post-Authorization Studies on Marysville Lake*

In 1972 I assumed responsibility for on-going post-authorization studies of the Marysville Lake multiple-purpose reservoir project on the Yuba River. This was a project desperately wanted by the local people because urban areas near the junction of the Yuba and Feather Rivers had been flooded due to levee failures several times in the last 50 years. The project plan included flood control, irrigation water supply, recreation, and a large pumpback power installation. The study addressed impacts on prehistoric and historic cultural sites, spawning areas for salmon and steelhead, water quality and heavy metals--particularly the presence of mercury from old gold mining operations, etc. It was a very interesting and challenging study, and we had an extensive public involvement program. When I retired in 1977, we had just completed the post-authorization study. The state did not support the project at that time--I think probably for political reasons; it appeared that the state wanted to construct the project, with the federal government contributing for flood control, as had been done for Oroville Dam on the Feather River. Due basically to lack of state support, the project was not funded for construction. However, California still needs the power and water supply the project could provide, as well as flood protection.

***Environmental Impact Statements***

One of the most interesting things I did in Sacramento was writing Environmental Impact Statements [EISs] after the passage of NEPA. There wasn't any guidance in the early '70's and the law is not specific as to what studies are required and how they are reported. The Chiefs Office asked the districts to prepare Environmental Impact Statements on various types of projects. I did several for Sacramento: one for a local protection project, one for a navigation project, and one for the Cottonwood Creek dams. The Chiefs Office took the statements from the various districts and from them they developed an overall outline and criteria for writing Environmental Impact Statements. It was very interesting.

Q: The Environmental Impact Statements really changed the way the Corps worked.

A: They changed what the Corps could do, as well as how they worked, yes.

Q: To lengthen the process by a considerable amount?

A: The way the environmentalists used the law to delay projects was really sad. At that time, inflation was about 10 percent a year. For even very good projects a two-year delay could result in the benefit-cost ratio dropping, making the project infeasible.

Q: Because the costs had escalated so much?

A: Yes. The cost escalated, and we did not escalate the benefits.

Q: How much did the EIS affect the way you did your work at Sacramento District? Did it delay your projects, or did it lead to some. . .

A: I think that the EIS process did not delay the projects as much as the lawsuits filed by environmental interests. For New Melones Dam, for example, we were in court several times over a long period as environmentalists filed a series of suits. There was much distrust and so much anirnosity between the environmentalists and the Corps people.

I was lucky. Irene and I went to the Galapagos to birdwatch in the fall of [1973] at the peak of the controversy over Morrison Creek. (The Galapagos Islands were not a tourist destination at that time.) Members of the Sierra Club asked me to show my slides at a meeting. That improved personal relationships considerably. At about the same time, the

president of the Sierra Club was quoted as saying, "The end justifies the means." They exaggerated and misrepresented facts on the basis that the end justified the means. That's pretty hard to deal with when you're operating in good faith and within the limits imposed by the Congress. We were continuously updating the same reports each year as prices escalated, and were doing nothing really constructive. That's why I retired.

Q: Or giving depositions or something, I imagine.

A: Or in court.

Q: So that early '70's period was a very difficult time for the Corps across the board?

A: The thing is the Corps was really trying to implement NEPA in good faith within the limits of our authorities.

Q: What was the general attitude in the organization at that time, fairly defeatist?

A: No, the attitude was, "We're doing the best we can." Sacramento District had a recreation section in the planning branch before NEPA, and it became the environmental section in the early '70's. We had wildlife biologists, archaeologists, and recreation specialists. They had to interact with the State Fish and Game Department, and the National Fish and Wildlife Service more than we did. One of the agencies that caused us the biggest problems was State Fish and Game. Their approach seemed to be to demand "as much as the traffic would bear." What they wanted in mitigation was totally unreasonable in many cases.

Q: I've heard from a lot of people that the Fish and Wildlife Service was the worst federal agency they had to deal with, as far as a lot of their projects were concerned.

A: As far as federal, probably, but in Sacramento, even the Federal Fish and Wildlife Service had a problem supporting the demands of State Fish and Game.

Q: So they had trouble?

A: Yes. Basically, I think we understood the environmental problems better than the environmentalists understood the engineering. I was a bird watcher long before NEPA, back

in Omaha in the '50's so I'm not unsympathetic to their point of view. I was unsympathetic to their ethics.

Q: Did they actually have any trained engineers, civil engineers, that worked with them?

A: No, but they hired consultants who would come in to look at our work for a short period and claim our computations were wrong and theirs were better. In general the consultants did not understand the rationale underlying our assumptions and the details of the studies. Corps projects and studies are complicated, and a lot of basic information is needed; hydrologic data, stream flow data, and so forth. We spent months doing what their consultants tried to redo in hours, always starting from the assumption that our computations were wrong and slanted to justify the project. Even statements in some of the Environmental Impact Statements prepared for us by environmental firms we hired were so biased that we had to ask for revisions.

Jerry Brown was Governor of California at that time and the heads of many of the state agencies appointed by him were attorneys from the eastern U.S. The head of the state Department of Water Resources was an attorney, although they had an engineer in the position of "chief engineer." It was a very bad situation in that politics, rather than engineering, seemed to be their foremost consideration.

Q: Well, you were probably in one of the worst states to have this thing happen to you because of its environmental community, especially up in that northern part of California.

A: I'm sure. NEPA enabled the Corps to do things that previous legislation didn't. But the environmentalists didn't understand that we couldn't do something just because they thought it was right when we had no authority to do it. They didn't understand the legislative mandates. You know, I think with time, a lot of it has worked out, but that was a bad time.

Q: So bad that it basically drove you out.

A: Yes. After seven years and so little progress, it appeared to be a no-win situation.

Q: Well, you would have been at the real cutting edge of dealing with these things in planning at that time, because planners were the ones that had to handle all of this.

A: Yes, we did. But even Irene in the design branch ended up in court in San Francisco on New Melones, on flows. I wasn't involved in the New Melones project, but when the dam was essentially complete, an environmentalist chained himself to a rock somewhere in the wilderness area of the reservoir to prevent storing water in the reservoir. Do you know about that?

Q: Yes, they were going to fill the pool, wasn't it?

A: Yes, they were about to start filling the pool and they couldn't find him. He would have drowned if the reservoir had been filled on schedule. It takes California, I guess, for something like that. I was in California last week, and things really don't seem to have changed very much.

Q: Now, so you really got away from the engineering aspects when you got into planning?

A: No, not entirely. In planning we had to understand the problems and engineering aspects.

Q: But your interests must have moved into more of the planning and the larger aspects of water resource development?

A: Yes, it did. It was broader.

Q: Which, as you say, include a lot more complex things than just structures or hydraulics.

A: Yes.

Q: Well, it might be appropriate to call a halt.

A: I think so.

Q: Is there anything you want to mention about your experience in Sacramento to sort of sum it up?

A: I think that it would be well for you to interview either Amalio Gomez or Bill Doyle, or maybe both, because they can tell you the whole story of the Corps in northern California.

They were in the Sacramento District from the early '40's. Gomez was Chief of the Engineering Division when I went there, and Doyle was Chief of the Planning Branch most of the time I worked there. There's a lot in California that has to do with the relationship between the Bureau of Reclamation and the Corps. The Corps built several large multi-purpose storage projects that were turned over to the Bureau for operation. The Corps continued to control operation of the reservoirs for flood control storage in the flood control space, setting flood control releases and so forth. The Bureau was interested in optimizing power production and, therefore, in keeping the reservoir as high as possible at all times. We had day-to-day conflicts over releases each time we had a major flood.

Q: That was a very unusual relationship, between the Corps and the Bureau, that didn't normally take place.

A: No, it didn't, but it did in California.

### *Retirement*

A: So in November '64 I went to Sacramento, and I worked there until '77 when I retired. I suppose that I really took an early retirement because of frustration with delaying tactics of the conservation groups. We no more than finished a feasibility study when the Congress passed another law; all the rules changed, and we redid the study. We redid the same thing year after year. With the high inflation rates of the early '70's, project costs escalated significantly each year and benefit-cost ratios steadily declined. Projects that had been economically feasible became marginal. Irene had a heart attack in '72, and she was having additional problems at that time. She died in '79.

### *Department of Civil Engineering and Engineering Mechanics, The University of Arizona*

In the fall of 1980, I was asked to come to Tucson to teach in the Civil Engineering Department of the University of Arizona. I didn't want to do it--I had never wanted to teach; public speaking was always very difficult for me. However, Emmett Laursen, whom I have known since we were undergraduates and who was on the faculty here, persuaded me to try. I was invited to teach because there had been a death on the faculty. They needed someone immediately, and they wanted somebody with a lot of experience. Actually, teaching was the most rewarding thing I have ever done. I taught only graduate classes, initially, and that led to the three books I have done. Most of our graduate students were foreign and they couldn't cope with stacks of notes. The first two books on planning and on river engineering

were based on my class notes. My chapters in the third book were based on lectures I had given at the University of Witwatersrand in South Africa.

***Publications and Consulting Work***

The first book I did was *Water Resources Planning and Development,* based largely on work I had done in Sacramento. The second one was *River Engineering* and the third was joint with David Stephenson of South Africa on *Water Resources Development in Developing Countries,* which was published in England.

Q: So it sounds like you've done some significant consulting overseas then?

A: Not really. I've done very little consulting, but I've done a fair amount of lecturing. I'm preparing a lengthy manuscript now on *Inland Navigation and Canalization* for the Chinese, and in October, I'm going to lecture on that in China in Beijing, Nanking, and Wuhan. The Chinese are interested in building navigation projects on a number of rivers. I visited the Three Gorges site a number of years ago, and the project is under construction. I'll get to go back and get another look at it.

Q: Well, that's a huge project, isn't it?

A: Yes, it is.

Q: I guess Lloyd Duscha's been doing some consulting with them on that on and off.

A: I don't know. Various people were, but then the American environmentalists raised so many objections to the project that U.S. support for it vanished, and the Canadians are now involved. I really don't know of any Americans who are still involved.

Q: I know in about 1978-79, Jack Morris was very much hoping that China would become the new Saudi Arabia, I think to replace it as far as a new source of work was concerned.

A: Right. The first time I was there was about 1987. Then I was there again about 1988. At that time, the Americans were still very much involved, the Bureau of Reclamation, especially.

Q: I think Omaha District was involved.

A: Was Omaha?

Q: I think MRD was involved because of their large engineering division out there.

A: Have you talked with Al Harrison?

Q: No.

A: He was initially in Omaha District in the mid-'50's and later in the Missouri River Division. He worked for Don Bondurant.

Q: Who's dead, I assume.

A: Yes, Don has been dead for at least ten years. In fact, almost all of key people in the hydraulic and hydrology work on the Upper Missouri are dead. Some of the geotech people may still be alive.

Q: So for all of the big dams up there, the key people from both MRD and the Omaha District aren't around?

A: I worked for Nick Barbarossa. I don't know whether he's still alive or not. I've lost track of him. But Tim Waara, who was head of our Water Utilization Section in the Planning and Reports Branch, died in the '70's. Bob Pafford was head of the Planning and Reports Branch. He may still be alive. Wendell Johnson was head of the MRD Engineering Division at that time, and he is dead. Al Harrison is probably the only one left.

Q: I heard that Pafford is alive. Frank Snyder said he was.

A: He left the Corps to become the regional director of the Bureau of Reclamation in Sacramento. He was in Sacramento when I worked there. Al Harrison was in Omaha in the '50's and just retired about a year ago.

***Emory Lane***

Q: What was Emory Lane like?

A: He was one of the kindest people I have ever known. When I took hydrology from him as an undergraduate, there were only two of us, one South American and me, so we met in his office. He didn't use the book; just talked to us. Actually, I took hydrology again at the end of graduate school when Joe Howe taught it. Lane had worked in China and had a daughter, who was a doctor; I believe she was in China at the time. He was especially kind from the standpoint of being willing to help a young woman.

Lane had certainly done a lot of interesting things. We visited him at the Bureau's lab in Denver in 1947 after we finished school and he had left Iowa; he showed us around the laboratories. We also saw him later when he was consulting for the Omaha District and we were at the Missouri River Division. He retired from the Bureau of Reclamation in 1953 and then taught at Fort Collins until 1957.

One of the things that I worked on for the Corps as an undergraduate was the design of a point-integrating sediment sampler. This was a joint project of the Corps, the USGS [U.S. Geological Survey], and I think ARS [Agricultural Research Service]. At that time there wasn't any reliable equipment for measuring suspended sediments in a river. I worked with Paul Benedict from the USGS on the design of the P-46 sampler, which was the first of a number of sediment samplers designed under that joint program.

We finished school in February 1947, and in July of '47, the Corps lab was moved from Iowa to the St. Anthony Falls Laboratory at the University of Minnesota.

***Sediment Sampling***

Q: How sophisticated was the sediment sampling technology at that time?

A: Up to that point? It was pretty crude. I remember Professor Lane came back from a conference once with a little sketch he'd made on tablet paper of a sampler design that was basically a milk bottle with just a little bit of tape around it. You had to manually open it. There had not been a lot of concern about sediment load until about this time when the Corps was beginning to seriously think about developing the Upper Missouri River. There hadn't been big sediment problems on the rivers on which the Corps had built locks and dams, but it was recognized that the Missouri would have a problem.

Q: Was this due more to other factors than just the rivers the Corps was working on then, because the Mississippi certainly has a huge sediment problem?

A: The Upper Mississippi does not carry much sediment; there are sediment problems on the Middle and Lower reaches of the Mississippi.

Q: But you don't have any dams on the lower part?

A: No, exactly.

Q: The upper part, isn't that where you get the load? It comes out of the Ohio and the Missouri then.

A: It primarily comes out of the Missouri; the Ohio doesn't carry very much sediment. There is some sediment transport on the Upper Mississippi, and a lot of those navigation pools have pretty well filled in now, except for the navigation channel, but they've been there sixty years or more. The poor foundation materials at the dam sites on the Missouri, I think, was one of the main reasons that those dams had not been built earlier. Foundations are something that engineers learned a lot about during World War II. I think people at WES, who had been active in airfields design and construction during World War II, applied what they learned there to geotech and dam foundation design on the upper Missouri River.

Q: So a lot came out of the work on those airfields?

A: A lot came out of World War II that enabled the Corps to design and construct dams on foundations previously considered unsuitable for a dam. The dam foundations on the Missouri are primarily shale.

***Morning Glory Spillway***

Q: How much came out of the work they had done on Fort Peck? Fort Peck's got a reputation.

A: Yes, it has. At the time I was in the Missouri River Division, there were problems with the "Morning Glory" spillway. Do you know what the intake looks like at Fort Peck?

Q: I've seen pictures of it, but since I'm not a trained engineer.

A: When they opened the gates and the spillway started operating, the spillway was very noisy and it could be heard for many miles. People complained about the noise.

Q: Can you describe a “Morning Glory” spillway?

A: It’s shaped like a morning glory. It has a circular crest, which transitions down to a much smaller, vertical conduit. There are gates around the rim of the crest. At Fort Peck these were vertical lift gates. When the gates were opened, the noise of the water going down into the tunnel--the spillway drops vertically and then turns 90 degrees--the noise factor was terrible. There was also vibration and cavitation. In the early '50's we were looking at how we could modify that spillway and we had a model study at WES in Vicksburg.

***Hunter Rouse***

Q: Did you know Hunter Rouse while you were at the University of Iowa?

A: Yes.

Q: Can you tell me about him?

A: Dr. Rouse was a very demanding person. I never had a course from him. The one year when I would have had a course from him, he was on sabbatical in France. But I knew him then because we worked in the lab and encountered him frequently. I knew him better later when he was a consultant to the Corps and through the work I’ve done with ASCE than while I was in school. The last time I saw him was in 1988. I’ve been active in the Hydraulics Division of ASCE since the early '50's. The ASCE Hydraulics Division has a national conference each year, and in 1988 I was chairman of a task committee that organized sessions commemorating the 50th anniversary of the division. The conference was in Colorado Springs, and Hunter Rouse was there. He was not doing very well at that time. I’ve had some notes from him since.

Dr. Rouse was one of the most influential people in hydraulics in this country. Rouse, Straub and Ippen from MIT had very broad interests. They and Einstein, whose major interest was sediment, were all consultants to the Corps on projects I worked on. Certainly Rouse’s books, especially his early books, were invaluable. I took Elementary Mechanics of Fluids from John McNown in 1945 using a purple ditto copy of the manuscript of Rouse’s second book, *Elementary Mechanics of Fluids,* which was published in 1946. Rouse was a consultant to the Corps for many years on many projects. He was one of our consultants on

the Mississippi Basin Model, as were Boris Bakhmeteff, Ippen, Straub, and M.P. O'Brien.

Q: Morrough O'Brien was also a consultant on the Board?

A: Yes, he was a consultant on the Mississippi Basin Model. We were working with a very distorted model, and we were not too sure of how applicable some of the results would be.

***Mississippi Basin Model Revisited and the Role of Computers***

Q: On the Mississippi Basin Model?

A: Yes. Are you familiar with that model? Have you been to Vicksburg?

Q: I've been to Vicksburg. I never was out to the one at Jackson.

A: There is a model of the Lower Mississippi River at Vicksburg. It's pretty much the same type of model.

Q: Right, which is all pretty much mothballed now, I think.

A: Yes. And so is the one at Jackson.

Q: I think the one at Jackson completely closed down.

A: Yes, I think it was turned over to Millsaps College, or one of the other colleges in Jackson.

Q: But they still use part of the one at Vicksburg, but they do so much inside now rather than outside, and so much with the computers.

A: Yes. I saw a video yesterday from the Huntington District of the Corps, a computer simulation of building a new lock on the Kanawha River. They have two small existing locks that they want to replace with a higher lift 11 O-foot lock. The video was a computer simulation showing how the existing locks operate and how a 1 lo-foot wide lock would operate. The simulation was very impressive; the video ran for 15 minutes.

One of the alternatives they showed was to remove every other cell along the guard wall, but they didn't comment about what this would do to the velocities in the lower lock approach, and I don't know how they could estimate that theoretically. They could save a lot of money if they took out every other cell which doubled the space between cells, but more of the spillway discharge would pass between the cells into the lower approach to the lock.When a tow enters the approach, there might be a problem. I don't know how they could examine that on the computer.

Q: Well, when you think of what they can do on computers, you think they could get that into it, too, wouldn't you?

A: This is three dimensional.

Q: With the computers now available, it's now a very different world than when you were first working in a hydraulics laboratory?

A: Yes, absolutely.

***Dam Break Studies***

Q: Did it basically change everything completely, when you got into computers?

A: I don't think so, initially. Computers have had more effect since I retired in 1977. I think computers have had a tremendous effect on hydrology, on forecasting, and hydrologic studies. Computers have greatly simplified sediment transport and backwater computations, which were terribly tedious.

One of the interesting things that we did in the early '50's in the Missouri River Division was to investigate failure of dams on the Upper Missouri. Gail Hathaway was concerned -- this was not too long after World War II -- about what would happen downstream if those large storage dams were breached. We ran some tests on the Missouri River section of the Mississippi Basin Model at Jackson that showed that failure of those dams would fill the valley bluff to bluff, all of the way down. You really didn't have to know the details; you knew that it would a disaster if it happened and especially if an upper dam were breached and overtopped the next one downstream, and that overtopped the next one, etc.We did some dam break computations manually, and they were without a computer and very tedious and difficult. Now dam break studies are done on the computer.

Q: It's no problem?

A: Right. Dam break studies are quite straightforward now.

***Foreign Influences on Hydraulics in the United States***

Q: I wanted to ask about foreign influences? We've already discussed some of the French influence on your work, but the Germans, the Italians, the Russian, the French, but especially the Germans, had done a lot of hydraulics. Of course? they supported the Freeman Scholars and all of those kinds of fellowships in the '30's and '40's. Did you notice a lot of that or was it unimportant?

A: When I was in Omaha and we were working on the sediment problems, river stabilization, and navigation channels, the best current material, the most practical material in the literature, was in the French magazine *La Houille Blanche*. I studied French while we lived in Omaha in order to translate articles in that magazine. I subscribed to that magazine for, I don't know, twenty years, maybe. I haven't for sometime, and in the meantime, the American literature caught up. There was a Frenchman, Antoine Craya, who published two papers on variable flow regimes in open channels in 1945, 1946, in *Houille Blanche*. We used his work in the dam break study on the Missouri.

When I was involved in designing the navigation project on the Arkansas River (1955-1964), I found virtually nothing helpful in the European literature at WES. (This was before the fire at WES in which they lost a lot of the older library material). However, some of the descriptive material in *Proceedings of the [Permanent] International Association of Navigation Congresses* (PIANC) concerning navigation development on European rivers was interesting.

John Davis probably will tell you that our early lock designs were influenced by European lock designs. Are you familiar with the Tennessee-Tombigbee Waterway?

Q: In general.

A: The "over and under" lock filling and emptying system design used at Bay Springs Lock on the Tennessee-Tombigbee (and on the other Corps high-lift locks) was derived from French designs. There was a hydraulic engineer in the Mobile District of the Corps, Francis Escoffier, who was French. He was familiar with this French design and introduced it to the Corps. I'm sure he's long dead because he was considerably older than me.

Q: So that's one of the most direct technology transfers that you could possibly think of?

A: That's fairly recent. Much earlier, in the 1930's, hydraulic modeling and river hydraulics in this country were greatly influenced by European practice, especially German, and in particular by early Freeman Scholars. John R. Freeman, a graduate of MIT [Massachusetts Institute of Technology], was active in hydraulic research, and in 19 13, on a trip to Europe, he was very impressed by the hydraulic laboratory at Dresden. On his return, he began actively advocating establishment of a national hydraulic laboratory in the United States. (Freeman was president of ASCE in 1922.) Freeman established three separate traveling scholarships, and the first six were granted in 1927, including one to Straub. A number of the early Freeman Scholars were Corps officers or employees or became Corps consultants. Straub was in Europe as a Freeman Scholar in 1927- 1928.

Many of the Freeman Scholars, as well as a number of Freeman's associates, translated into English the 1926 German book *Die Wasserbaulaboratorien Europas*, which described river-hydraulic laboratories in Europe. The translation, *Hydraulic Laboratory Practice,* was published by ASME in 1929.

### *Lorenz Straub*

Q: Now, what about your experiences with Straub? He was at the University of Minnesota?

A: Yes.

Q: Didn't he have a little hydraulics lab, the original little lab at the Falls of St. Anthony?

A: He's the one who built that lab in 1936- 193 7 with WPA [Works Progress Administration]. Prior to the war most work at St. Anthony Falls was related to Straub's sediment and river engineering studies. In 1930's he also translated two German books into English, Franzius's *Waterway Engineering* and Schoklitsch's *Waterways.* During the war (1942-45) Straub was with the National Defense Research Committee in New York. Straub probably was the person who was most knowledgeable in practical river hydraulics back in the '40's and '50's. He: was a consultant to MRD and attended meetings in Omaha about once a month when we were there. There was a lot of controversy at that time as to whether or not the dikes along the Missouri had changed flood levels. I was involved in that study, and he was a consultant on that project.

Straub was also a consultant to the contractor on closing Gavins Point Dam. Most of the Corps dams had been closed by contracting the river from both banks.On the Missouri at

Gavins Point Dam, the closure material was chalk which isn't very heavy and isn't very big. Straub developed a closure operation based on a friction closure, placing chalk with a drag line mounted on a barge across a wide blanket extending bank-to-bank across the closure section.

Talking about foreign influences, this type of closure goes back to work by Ishbash, who was a Russian. Ishbash did the original work on this, developing a dam closure procedure with a sill of minimum cross section. Straub called this "obstruction control" in contrast to his use of "friction control" by means of a wide blanket at Gavins Point. The closure section was on the left overbank and as the blanket was raised, more and more flow was diverted through the power plant on the right bank.

Q: So they would dredge it upstream and let it go down and settle in?

A: Well, they had the material stockpiled; it had come out of excavation for the power plant and other excavation work at the site.

***German Influence***

Q: Such foreign influence was important, but apparently the German influence was somewhat predominant in the 1920's and 1930's. I was fortunate enough to have talked to some people who did Freeman Fellow work and American Society of Mechanical Engineers (ASME) studies in Germany. A number of engineers from the Corps of Engineers did studies at the technical high school at Charlottenburg in the 1930's (now the Technical University). General Casey was always talking about all of his friends who had been over there on those scholarships and had completed major studies.

A: Yes. General Casey was a Freeman Scholar in 1933-34. Vogel was there in 1927-28 with Straub, O'Brien, and others. Haywood Dewey was a Freeman Scholar in 1940-41 and a number of other officers and civilian employees were also in the program. Vogel became the first director of WES in 1929 when he returned from Europe.

Q: So there was always this question because when you read Rouse's book, you find a lot of influence of German hydraulic engineering.

A: The German influence on fluid mechanics is very direct, I think, through Rouse and others who studied in Germany; Freeman and the Freeman Scholars; the Europeans, including Prandtl, Thoma, and Spannhake, who lectured here; and those who immigrated to the United

States, including Boris Bakhmeteff, von Karman, Ippen, and von Mises. Corps hydraulic work was greatly influenced by Freeman Scholars who had studied in Germany and also by consultants from the academic community.

Q: At least there are two examples we have there.

A: Yes, and I suppose if we keep talking, we'll come to some more of them.

Q: There are probably a lot more of them.

A: I remember that the Waterways Experiment Station used to have framed pictures of all of the old European hydraulicians in the halls of the old Hydraulics Division building going way back. Fortson was very interested in history.

Q: It's an intriguing point to see how much there is and then what was picked up in these contacts and actually transported back and implemented in various programs, especially when you begin having the international congresses like PIANC and all of the international papers.

***Hans Albert Einstein***

Q: We've discussed Straub, Lane, Bondurant, and others and mentioned "Young Albert" Einstein. What about Hans Albert Einstein? I gather he was a specialist in sedimentation.

A: Yes. He actually came and worked one whole summer with us in Little Rock on the sediment problem. That was before we got into the sediment routing. I didn't work with him then, but he was a very understated man, very nice, very quiet, very retiring. I've heard people say, "Do you think he'd be where he was if his name wasn't Einstein?" But sediment is one of those areas where many people have their own theories. Einstein was very helpful to us on the Arkansas River. I think that Bondurant appreciated his help on the Missouri as much as we did on the Arkansas.

Q: So Einstein wasn't as critical to you down in Little Rock as he had been in Omaha?

A: No, he was really more--Al Harrison, whom I suggested you contact, was his student at Berkeley. Al was just finishing his Masters when Irene and I transferred to Omaha. This is

a picture of all the hydrologists and hydraulic engineers in '64, after I left Little Rock. Jay Pyle, who had been the Chief of the Hydraulics and Hydrology Branch, had also left at that time. But there are young people in the picture who went on to make major contributions to the Corps. That's Tony Thomas. This is A. J. Fredrich, who did the *Sons of Martha* book.

Q: In the Little Rock District?

A: In Little Rock, yes. The picture includes our field party of three or four people. The Hydraulics Branch was a small group and most of us started there sometime about the middle '50's and it essentially broke up after Jay Pyle retired. I was the first one to leave. Irene left right after me. Then A. J. went out to HEC, and Tony Thomas followed him out there.

Q: Was that primarily because the work on the river had slacked off?

A: No, it was really because of the person who followed Jay Pyle as the Chief of the Hydraulics Branch, an appointment made by the district engineer without informing the division. The division was incensed and would have blocked the appointment had they known, because while he was a great talker, his knowledge of hydraulics was limited. Twenty years later, he was formally asked to leave, but the appointment essentially destroyed hydraulics in the district. It was too bad. However, the basic hydraulic work was finished for the whole project at that time, so in that respect it wasn't all that bad.

***Vito Vanoni***

Q: I asked you about Lorenz Straub and a little bit about Einstein. Vito Vanoni was another name I've come across, but I haven't found out much about him.

A: I think the last time I saw him he said something about not doing as much [consulting work]. He'd only been two or three places that year. He was a consultant to the Corps, but I think his most important contribution was the sedimentation manual he edited that was published by ASCE. Are you familiar with that?

Q: No.

A: I think it took about fifteen years to complete. The various chapters were written by various people and were published as papers in the *Hydraulics Division Journal* of ASCE. The manual was finally published in 1976 and Vanoni was given a special award for it. ASCE

is now, twenty years later, about to update the manual, but Vanoni's edition was comprehensive and covered all aspects of sedimentation. It was a major contribution and widely used.

Q: So you brought him in to both Missouri River Division and then, did you use him in Little Rock?

A: No. He was on a sediment panel with Lane on the Missouri River. I don't remember that he was one of our consultants on the Arkansas.

Q: That wraps up my questions. I want to thank you for spending the time with me and your willingness to share your experiences"