ALASKA LEGISLATURE COMMITTEE FILES 1991-1992 8672
7663 SENATE RESOURCES

treaties or bilateral agreements as might be appropriate, vessels discovered with contraband salmon on board, with such vessels to be sequestered in United States ports until disposition by the Federal Courts.

COPIES of this resolution shall be sent to the Honorable James A. Baker, III, Secretary of the U.S. Department of State; to the Honorable Robert A. Mosbacher, Sr., Secretary of the U.S. Department of Commerce; to the Honorable Samuel K. Skinner, Secretary of the U.S. Department of Transportation; and to the Honorable Ted Stevens and the Honorable Frank Murkowski, U.S. Senators, and the Honorable Don Young, U.S. Representative, members of the Alaska delegation in Congress.

SCR

18

Alaska State Legislature

Senator Paul Fischer
Senate District D
Box 784
Soldotna, Alaska 99669
(907) 262-9420 W
262-9269

State Senate

While in Juneau
P.O. Box V
Juneau, Alaska 99811
(907) 465-3791

MEMORANDUM

TO: Senator Lloyd Jones, Chairman
Senate Resources Committee

FROM: Senator Paul Fischer PF

SUBJECT: Senate Concurrent Resolution 18
(relating to the sale and transfer of surplus Alaska water to California)

DATE: March 19, 1991

I would appreciate your scheduling the above referenced resolution for a hearing before the Senate Resources Committee at your earliest possible convenience.

I have attached backup information for the committee files. A fiscal note has been requested and should be forthcoming from the Department of Natural Resources.

Your consideration would be greatly appreciated.

PAF/sgn

Attachments

7-LS0953\J
Bannister
4/16/91

CS FOR SENATE CONCURRENT RESOLUTION NO. 18 ( )

IN THE LEGISLATURE OF THE STATE OF ALASKA

SEVENTEENTH LEGISLATURE - FIRST SESSION

BY

Offered:
Referred:

Sponsor(s): SENATOR FISCHER

A RESOLUTION

Encouraging Governor Hickel to work in cooperation with the State of California and the United States Congress to arrange for an initial feasibility study of an Alaska-California fresh water pipeline.

BE IT RESOLVED BY THE LEGISLATURE OF THE STATE OF ALASKA:

WHEREAS the shortage of water in California has become an increasingly serious problem for its citizens, businesses, and agricultural interests; and

WHEREAS fresh river water that is surplus to the needs of Alaska is presently flowing into the Pacific Ocean from Alaska while parts of California are suffering critical water shortages; and

WHEREAS Governor Hickel has publicly announced his interest in sharing Alaska's immense renewable surplus of fresh water by piping the resource to the states on the west coast; and

WHEREAS modern technology and engineering capabilities make it feasible to construct a fresh water pipeline extending from Alaska to California; and

WHEREAS an interstate compact agreement between Alaska and California could be executed to arrange for the sale of the water and the construction of the pipeline; and

WHEREAS Assemblywoman Lucille Roybal-Allard has introduced into the California Legislative Assembly Concurrent Resolution 31, which urges California Governor Pete Wilson to direct the

immediate start of an initial feasibility study for the construction of the Alaska-California pipeline; and

WHEREAS H.R. 1600, which has been introduced by Representative Edward R. Roybal into the U.S. Congress, would request the U.S. Secretary of the Interior, acting through the U.S. Bureau of Reclamation, to conduct an initial feasibility study for the pipeline; and

WHEREAS Representative Edward R. Roybal has also introduced H.J.R. 186, which would request the President of the United States to conduct an initial feasibility study for the pipeline; and

WHEREAS the diversion of Alaska water to the areas in California that are experiencing severe water shortages would greatly benefit the growing population of California and its agricultural and industrial concerns, and the proceeds from the sale of the water to California would benefit the citizens of Alaska;

BE IT RESOLVED that the Alaska State Legislature encourages Governor Hickel to work in cooperation with the State of California and the United States Congress to arrange for an initial feasibility study of an Alaska-California fresh water pipeline.

COPIES of this resolution shall be sent to the Honorable George Bush, President of the United States; the Honorable Dan Quayle, Vice-President of the United States and President of the U.S. Senate; the Honorable Thomas S. Foley, Speaker of the U.S. House of Representatives; the Honorable Manuel Lujan, Jr., Secretary of the U.S. Department of the Interior; the Honorable George Mitchell, Majority Leader of the U.S. Senate; the Honorable J. Bennett Johnston, Chair of the U.S. Senate Committee on Energy and Natural Resources; the Honorable Ernest F. Hollings, Chair of the U.S. Senate Committee on Commerce, Science and Transportation; the Honorable Quentin N. Burdick, Chair of the U.S. Senate Committee on Environment and Public Works; the Honorable George Miller, Vice-Chair and Acting Chair of the U.S. House Committee on Interior and Insular Affairs; the Honorable Robert A. Roe, Chair of the U.S. House Committee on Public Works and Transportation; the Honorable Pete Wilson, Governor of the State of California; the Honorable Ted Stevens and the Honorable Frank Murkowski, U.S. Senators, and the Honorable Don Young, U.S. Representative, members of the Alaska delegation in Congress; the presiding officer of each house of the California State Legislature; the members of the California State Legislature; the Honorable Kenneth Hahn, County of Los Angeles Board of Supervisors; and to the Honorable Dennis B. Underwood, Commissioner of the Bureau of Reclamation in the U.S. Department of the Interior.

...complaints against police over the past five years.

The most striking thing about the statistics may be how much they vary, suggesting the colossal proportions of the task facing the U.S. Justice Department. The agency was ordered by Attorney General Dick Thornburgh ir. the wake of the Los Angeles incident to review the use of force by police nationwide.

The figures that are available from local law enforcement agencies for the past five years only prove the futility of jumping to any conclusions about trends in police brutality.

There has been a rising number of complaints by residents of Cincinnati, Honolulu, Chicago, and Rochester, N.Y. There have been fewer complaints in San Francisco and New York. And the number has fluc-

...Baltimore; Richmond, Va.; Oklahoma City, and Boise, Idaho.

The Rodney King beating, captured on video by an amateur, instantly made police brutality a national issue, and police beatings elsewhere in the past few weeks have received far more attention than they might have otherwise.

In Columbus, Ohio, the American Civil Liberties Union said it has been getting double its usual number of

Outlook for West still dry

By RANDOLPH E. SCHMID
THE ASSOCIATED PRESS

WASHINGTON – Despite recent storms, drought threatens much of the West as the dry summer season approaches, federal water experts said today.

Dry conditions have plagued California for some five years and the outlook for this year "is not good news," said Frank Richards of the National Weather Service.

"Basically, what they've done is they've run up quite a (water) deficit. You're not going to pay that off with one or two major storms," Richards said in issuing the annual spring report on the nation's water supply.

Originally a flood report, the water outlook this year concentrated much more on persistent dry conditions in California, Nevada, Utah, Oregon and North Dakota.

The Missouri and Colorado river systems face water shortages as well as the West Coast, the report said.

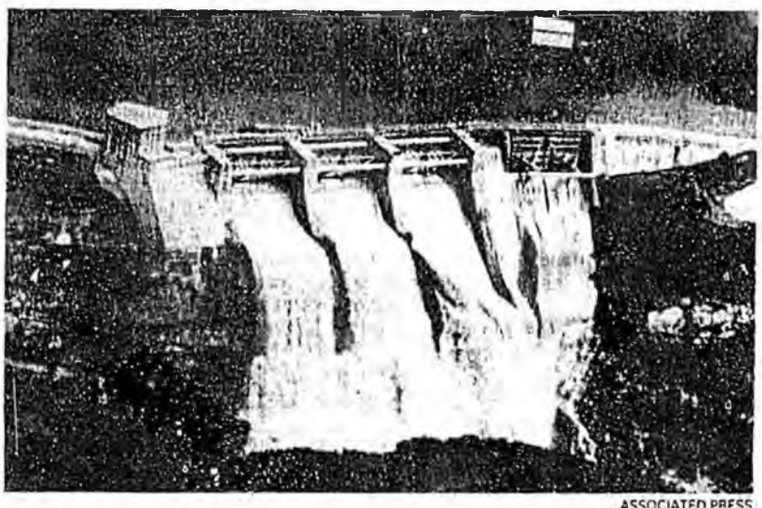
For the record, states along the Eastern seaboard from mid-New Jersey south to northern Florida and west to the Mississippi River basin face potential flooding, if strong storms should occur.

While recent storms have only raised California reservoirs to half full, at best, there have been benefits, Richards said.

For example, the rains have reduced the forest fire potential in the West and have moistened soils enough to allow future snowmelt runoff to add to reservoirs when it arrives.

But major water supply problems continue, caused by the natural variability of weather coupled with the rising population of California and increasing demand.

ASSOCIATED PRESS



ASSOCIATED PRESS

Before and after: The Gibraltar Reservoir in Southern California's Santa Barbara County was bone-dry in April 1990, top, but overflowing after rains last week, bottom. Still, forecasters say recent storms are not enough to end drought conditions.

Moderate quake jolts

L.A. takes look at water line

County hires engineers to study proposal

By RALPH THOMAS
THE JUNEAU EMPIRE

Gov. Walter J. Hickel's vision of a double-barreled freshwater pipeline from Southeast Alaska to California is getting some serious attention in parched Los Angeles.

Hickel received a letter this week from a Los Angeles politician who has convinced the county to hire an engineering firm to study the pipeline idea and provide a cost estimate for the 2,000-mile supply line.

The idea has been around for a long time, but started getting renewed attention after Hickel mentioned it in January at a National Press Club luncheon in Washington, D.C.

California has been suffering through a long drought and numerous local governments there have imposed water-use restrictions during the past year.

In a letter to Hickel, Kenneth Hahn, a Los Angeles County supervisor, said the engineering study was approved unanimously by the five-member Board of Supervisors last weekend.

"I am very optimistic about this proposal and I look forward to meeting you in person in the near future," Hahn wrote.

Hahn also said he had asked several county officials – including the public works director and the county's chief administrator – to visit Hickel in the near future.

Victoria Pipkin, a press aide for Hahn, said county officials already have made travel plans to Alaska, but she didn't have any details.

Pipkin said the idea is getting serious consideration in California, noting it has been the topic of at least two front-page stories in the Los Angeles Times. She said she hadn't heard anyone ridicule the proposal, but said there certainly will be doubters.

"Don't you guys have a pipeline up there?" she said. "I'll bet a lot of people said that was impossible, too."

Hickel has suggested a twin set of 20-foot-diameter plastic pipelines that could be laid on the ocean floor from Alaska to California. Under his idea, water would be captured from Alaska rivers and pumped through the pipeline

Circling with them were gas tanker planes, which allowed the warplanes to top off their tanks just before leaving for their targets inside Iraq.

The first targets were Iraqi radar installations, which had to be knocked out quickly if coalition

never recovered." [illegible] that's what they did."

By the ninth day of the war, most Iraqi planes had been hidden in concrete bunkers, and when coalition planes began striking those targets, Iraqi pilots began their exodus to neutral Iran.

The general affirmed earlier assessments that the hunt for Iraq's mobile "Scud" missile launchers slowed down the air campaign by about a week. Also bogging down the operation was the gulf region's worst weather in 14 years, he said.

KEVORK DJANSEZIAN / The Associated Press

...ore Briseno, right, and Laurence Powell, two of the ...ngeles police officers indicted Friday for beating a ...ist, arrive at court to hear charges against them.

Californians plan to tap B.C. water

By MARIA L. LA GANGA
Los Angeles Times

GOLETA, Calif. — With its back to the wall and the fate of a $52 million agricultural industry at stake, the Goleta Water District selected a company early Friday morning to ship Canadian water to this thirsty Santa Barbara County coastal community by supertanker, the first time such a drastic action has been taken in the United States.

But contract negotiations with the company that was chosen and a complicated permit process still stand between Goleta and the costly water from British Columbia.

"We are committed to moving ahead with this," said Katy Crawford, president of the water district board. "The main thing that would stop us is the permitting process, which is horrific. ... But it has to happen within the next year, because a year from May our reservoir, Lake Cachuma, will be dry."

If Lake Cachuma runs dry and no new water is available, several board members said, there would be enough water for urban use, but agriculture would have to be cut off. The result; $52 million in lost crop value and 750 to 800 lost jobs.

Faced with its reservoir running dry, Goleta chose what many consider to be an outlandish remedy. Other options, such as joining Santa Barbara in constructing a desalination plant are in the works, but won't get the district enough water in enough time.

Under normal circumstances, the water district uses 16,000 acre feet of water each year. Today, its 70,000 residents are scraping by with 10,000. Mandatory rationing has been in place for nearly two years. Desperate avocado growers have begun cutting down trees because of the drought. So in Goleta, Canadian water is not considered exotic, but necessary.

"Exotic is something that occurs when you have a variety of alternatives, and you have the resources to exercise your fancy," said Patrick Mylod, one of five district directors. "Basically, if tankering doesn't work, our agricultural industry is out of business for at least two years."

The district plans to ship an estimated 7,500 acre feet of water a year from British Columbia, an area that averages more than 150 inches of rainfall annually, compared to Goleta's six inches in 1990.

Ships loaded with Canadian water would dock at an as-yet-unspecified spot near Goleta and deposit their loads into a pipeline that would take the water to the district's treatment plant. There it would be distributed via normal channels.

The project, which could run up to seven years, would cost more than $22.5 million annually.

Anchorage Daily News 3/16/91

Californians Faced with $13 Billion Budget Deficit

SACRAMENTO, Calif. (AP) — An unparalleled $13 billion budget deficit over two years, with roots in the Proposition 13 tax rebellion, means residents of the nation's most populous state will soon be paying more for less.

"We could close all our state universities, we could open all our prisons, we could eliminate our entire state workforce — and we would still not close this gap," said Gov. Pete Wilson.

The projected shortfall is the largest ever faced by any state, according to the Department of Finance.

Californians could be paying higher sales taxes, higher liquor and motor vehicle taxes and higher college tuition. One proposal would tax services, such as those provided by attorneys, architects and plumbers.

Public schools and colleges will likely have larger classes and fewer courses, teachers and state workers could lose their jobs, and fewer health, mental health and welfare programs will be available for the poor.

Last July, lawmakers thought the current year's $55 billion budget was balanced with a $1.4 billion reserve. Instead, there will be a record $3.6 billion deficit by the time the fiscal year ends June 30.

And next year's proposed budget, a $55.7 billion spending plan for 1991-92 which Wilson proposed in January and takes effect July 1, is projected to have a deficit of more than $9 billion.

The crisis already prompted Standard & Poor's Corp. to place the state, which has had top credit ratings from the three main New York bond houses, on a credit watch. That means the rating agency is considering reducing the state's AAA rating.

"The numbers have gotten larger and we have seen little or no action to reduce that gap. That's what troubles us," said Richard Larkin of S&P.

Determining what taxes to raise and what services to cut presents a daunting challenge to the Republican governor and the Democrat-dominated Legislature.

Wilson and most legislators agree fast action is needed. He has asked for passage of a budget plan by May 1. While lawmakers are skeptical they can meet that deadline, leaders hope they can reach agreement before the fiscal year begins.

"What we're talking about is aggravating the situation by any delay," Wilson said. "If we do not begin making the cuts, the hole grows deeper."

Wilson and most legislators agree that filling the gap will require a combination of deep cuts and sizable tax increases, since the budget cannot be realistically balanced by either taxes or cuts alone.

Wilson has already begun closed-door negotiations with the top four leaders of the Legislature. Passing a budget requires a two-thirds vote in each house.

Water pipeline finds a backer in Washington

By BRIGID SCHULTE
States News Service

WASHINGTON — It's being called the Mother of All Water Hoses.

Whatever the nomenclature, and despite the rolled eyes and snickers, Alaska Gov. Wally Hickel's massive vision of a freshwater pipeline running along the ocean floor from Alaska to California has just got its first foothold in Congress.

Rep. Edward Roybal, a California Democrat from drought-ridden Los Angeles, last week introduced a little-noticed resolution calling for a feasibility study for a 2,000-mile-long North American Water Transfer Engineering Facility. If adopted, the study would be completed by September.

The resolution noted that the southward flow of water in the pipeline would be "enhanced in its long journey by the Earth's rotation," which would lessen the need for mechanical pump stations. It also left open the possibility of tapping fresh water resources along the way, in the fiercely protected Columbia River basin.

This week, Roybal, a 14-term lawmaker who met here with Hickel recently, is expected to attach the study in the form of an amendment to the emergency California drought bill t House will debate.

Rep. Jim McDermott: Critic of plan

Roybal said that the "i novative" pipeline, to planned, financed and ope ated by an interstate pub pipeline authority, wou permanently solve Calif nia's water supply proble

Although Hickel has m tioned building such a pi line along the continen shelf for more than 20 ye the idea is still new eno — and outlandish-sound enough — to cause most c

Please see Page B-3, WA

WATER: Plan finds a backer

Continued from Page B-1

gressional aides to answer questions with stunned silence.

But some staunch water-transfer critics from Pacific Northwest delegations say pumping water south from Alaska will only feed California's wasteful water habit and ultimately sap the Pacific Northwest.

"To go from Alaska to California, you have to pass through the Pacific Northwest," said Rep. Larry LaRocco, D-Idaho. "California has coveted the water in the Northwest for a long time. But the Columbia and the Snake are working rivers, used for hydroelectric power, shipping, navigation and for crops. . . . We're strapped as it is."

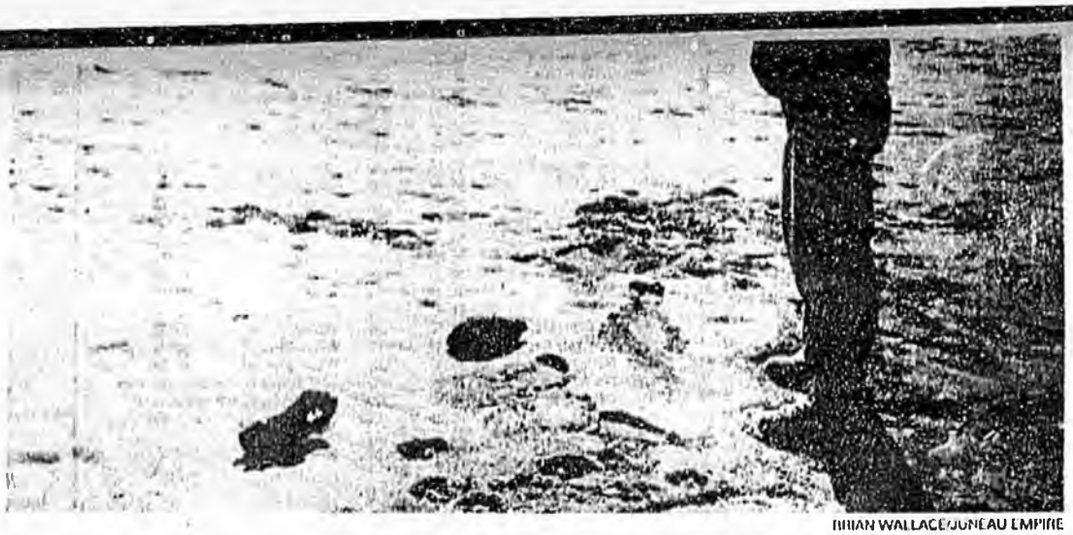
Rep. Jim McDermott, D-Wash., agreed, saying California should seek to solve its water-use problems internally before reaching north for additional stores.

Both lawmakers say building an Alaska-California pipeline would open the door to siphoning off Columbia River water — which Northwest lawmakers for 40 years have fought. Since 1986, federal agencies have been permanently barred from even studying Columbia River water transfers to California.

A spokesman for Rep. Pete DeFazio, D-Ore., said the lawmaker would only "shake his head and smile" at the pipeline project.

"Many water diversion proposals strike many Northwesterners as fundamentally screwball," said DeFazio spokesman Bob Hennessey. "But sending Northwest water to people who choose to live in a California coastal desert so they can keep their lawns green and hot tubs full . . . doesn't seem to be a very efficient use of what's becoming a scarce resource."

Articles



BRIAN WALLACE/JUNEAU EMPIRE

ion prepares to launch an airfoil kite Sandy Beach in Douglas as area resi- yed perfect kite-flying weather – sunny and breezy. According to the National Weather Service, however, clouds will return tonight with occasional rain predicted for Tuesday.

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Pipe dream? Hickel proposes water line to parched California

By LEE DYE
LOS ANGELES TIMES

OK. So it sounds a little wild. But maybe, just maybe, it would work.

Alaska has more fresh water than any other place in North America. Southern California has a drought. So take two or three billion gallons of water out of some of Alaska's rivers each day and ship it down to Los Angeles through a giant plastic pipe laying on the bottom of the ocean.

"It can be done," said Walter Hickel, Alaska's governor, a man who carved his personal fortune out of the Alaskan economic wilderness and likes to dream of "world scale projects."

And true to his entrepreneurial past, Hickel does not want to give the water to California. He wants to sell it, but at a reasonable price, of course.

The basic concept is fairly simple, and some experts said that it might be technologically feasible. Others, however, say the feat – involving factors like the spin of the Earth – is considerably more complex and fraught with potential problems.

> 'Think of the pipeline as a big garden hose. You plug it into a river here and then you plug it into L.A. down there.'
>
> **– James Rockwell, Gov. Walter J. Hickel's special projects aide**

Beyond that, whether the pipeline would be worth what it would cost is an unanswered question.

Hickel believes the pipeline could be built on the back of a huge barge and lowered to the sea floor like a big garden hose as the barge moved south. And because it would be under the sea, the pipeline could be built of reinforced plastic instead of the concrete and steel that would be needed to withstand the rigors of a land route.

In addition, laying the pipeline offshore would sidestep most of the environmental and legal problems that have blocked many efforts to transport huge amounts of water over land and across various jurisdictions, he said.

Hickel has been promoting the idea ever since an even more ambitious plan to dam up many of the rivers across North America ran into economic and political difficulties in the 1960s. No one paid much attention to Hickel's proposal until the current drought, but as the water shortage has worsened, more and more experts have begun to treat it seriously. The pipeline, however, would be designed to meet long-term water problems in the Southwest, not just the current drought.

Rep. Edward R. Roybal, D-Calif., has introduced legislation in Washington that would require a feasibility study of the proposal. His daughter, Rep. Lucille Roybal-Allard, D-Calif., has introduced a similar resolution in the California Legislature. And the Los Angeles County Board of

Please turn to Water, Page 8

.....Page 16
s .....Pages 15-16
Abby .....Page 17
Once Over Lightly.....Page 2
Opinion .....Page 4
Stocks/Money.....Page 7

WEATHER

occur 70 miles to 100 miles above the Earth, but the red coloration occurs when the electrical storms are about 300 miles above the planet, he said.

The aurora borealis usually can be seen only near the Arctic Circle, but the lights can be visible farther south when large solar flares dump large amounts of

...has not stopped yet, Brown said.

Fairbanks residents saw a red northern lights display early Wednesday evening and a weaker red tinge was seen Thursday night, he said.

Though the lights are common in arctic regions, reports of the aurora borealis as far south as Georgia and the Gulf of Mexico "puts it right up there as being one of the really rare ones," Brown said.

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Water...

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Supervisors adopted a resolution in support of the studies.

Nobody knows what such a project would cost, although one expert estimated that it is in the "hundred billion dollar class." No one has built such a pipeline before, so it is not clear just how difficult the technological problems might be. But some believe it is not beyond the realm of possibility, at least from a technological standpoint.

"You can do it technologically, but is it economically feasible?" asked Nathan W. Snyder, director of technology for the Ralph M. Parsons Co. of Pasadena, Calif., and one of the world's leading experts on huge water projects. And even from an engineering standpoint, "there are a lot of problems associated with it," Snyder said.

Yet he said that he could not rule it out.

Let there be no mistake about it, though, we are talking Big here.

Hickel envisions two pipelines, each 20-feet in diameter, running 2,000 miles from the west coast of Alaska to Southern California. Others interested in the idea see pipelines 36-feet wide, or even larger.

John Dracup, professor of civil engineering at the University of California, Los Angeles, who believes the proposal is "technologically feasible," said the "economies of scale" would dictate the size of the project.

Hickel put it more simply.

First you decide how much water you need, and then you build a pipeline big enough to carry it. Hickel said in a telephone interview.

The economic problem results from the relatively low value of water. "Water is cheaper than dirt," said a spokesman for the Los Angeles Metropolitan Water District, so the pipeline would have to move a lot of water to generate enough revenues to pay for itself.

Hickel said that Alaska would charge only a small fee for the water, about "a penny for 20 gallons, or whatever." Asked if that would mean significant revenues for his state, Hickel just chuckled. Assuming the pipeline moves 2 billion gallons a day, that would add up to $1 million a day for Alaska.

But the main cost would be in building the pipeline and moving the water from Alaska to California.

If the pipeline cost $100 billion, and lasted about 30 years, the water it would deliver could cost at least as much as desalinated water, and that would make the project economically doubtful. If the cost could be brought down considerably, that margin would improve.

But nobody knows for sure what it would cost, or even if it could be done.

Asked what he thinks the pipeline would cost, Hickel said, "I never got to that."

The concept is basically "a very simple idea," said James Rockwell, Hickel's special projects aide.

"Think of the pipeline as a big garden hose," Rockwell said. "You plug it into a river here and then you plug it into L.A. down there.

"You build it off the back of a 1,000-foot barge in 300-foot sections," Rockwell said. "You fit them together on the barge, and then you lower it into the water.

"So the whole line is laying off the back of this barge, and a mile back its resting on the ocean floor. You lay it down like a big hose," he said.

The water would come from reservoirs built near the mouth of one or more of Alaska's rivers. Thus the water would be captured just before it flows into the ocean, so no one in Alaska would have to give up their water rights.

Once filled with fresh water, the pipeline would be lighter than the ocean's salt water and it would tend to float, so it would have to be anchored to the bottom.

But Parsons' Snyder sees problems with that idea.

The continental shelf beneath the Pacific "is not a nice, smooth sandy bed like a lot of people think," Snyder said. "There are some deep gorges, and if you put a pipe across one of those things you will crack it."

What if the pipe were to leak a little? Rockwell said that it would simply mean a little fresh water would escape into the ocean and cause no harm.

However, "the maintenance problems would be enormous," said Snyder. He envisions robotic submersibles and diving crews that would have to service the entire pipeline. Even a small crack could become a major problem because the water inside would be under considerable pressure.

The water probably would have to be pumped at the rate of 5 or 6 feet per second, and that would create pressure within the pipe of around 50 pounds per square inch.

"When you get a large pipe, the stresses get pretty big," said Snyder, who has worked on major pipeline projects around the world.

It would also take a lot of energy to pump the water south, possibly 1,000 megawatts, which is equivalent to that produced by a major nuclear power plant.

Rockwell agrees that the water would have to be pumped, but he said that the energy required may not be as great as some believe because of something known as the "Coriolis effect." That is caused by the spin of the Earth, and some believe the water could be helped along by it. It is the same phenomenon that causes water to form a whirlpool as it swirls down a drain.

The water would be traveling in a Southeasterly direction, and the Earth spins toward the west. Thus the Coriolis effect, according to theory, would cause the water to move down the pipeline as the pipeline itself moves west.

Several experts said they doubted that that would have much of an effect, but they said that they would have to think about it a little more.

That is the sort of question that will have to be addressed in a feasibility study like the one sought by Roybal. Austin Hogan, an aide to Roybal, said the congressman got interested in the proposal after concluding that the idea "is not ridiculous."

"It's all off-the-shelf technology," Hogan said. He estimated that the feasibility study would cost about $200,000.

Hickel says he is not troubled by the chances that many will brand his idea as too ambitious.

"Hell, that's what they said about the (Trans Alaska) oil pipeline," he said.

But he quickly added, "We're not pushing it. If they have a water problem, I'm just giving them an idea of how they might solve it."

The proposal is ambitious, he said, but that is what the situation calls for.

"You have to think big because the problem is big," he added. "You aren't going to solve it in a small way."

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An abstract of technical articles on underwater pipes (ocean floor)

Sue Samson

P.O. Box G, Juneau, Alaska 99811-0571
(907) 465-2910

Publication Year: 1990
CODEN: JWPED5 ISSN: 0733-950X
Language: English
Document Type: JA; (Journal Article) Treatment: X; (Experimental); T; (Theoretical)
Journal Announcement: 9103
Abstract: An experimental study is conducted in order to identify the major physical processes leading to the breakout of half-buried submarine pipelines from the seafloor under ocean-wave action. Both the hydrodynamic loading on the exposed surface of the pipe as well as the pore-pressure distribution on the buried surface were measured. The resulting displacement histories of the pipe were recorded and analyzed in order to identify the critical pipe-soil-wave conditions for the detachment of the pipe from the seabed. The paper examines the balance of the pipe under the combined lift and drag loading from the water wave. The experimental coefficients of drag, lift and added mass have been calculated by the least squares method and compared with theoretical predictions. As for the soil response, a simple theoretical model is worked out to describe the pore-pressure resistance force at the soil-pipe interface. An experimental breakout force-time power law is obtained and compared with the theoretical model. (Author abstract) 21 Refs.
Descriptors: *PIPELINES, SUBMARINE--*Wave Effects; WATER WAVES--Effects; HYDRODYNAMICS; SOILS--Underwater
Identifiers: HALF-BURIED MARINE PIPE BREAKOUT; SUBMARINE PIPELINE BREAKOUT FROM SEAFLOOR
Classification Codes: 619 (Pipes, Tanks & Accessories); 931 (Applied Physics); 631 (Fluid Flow & Hydrodynamics); 471 (Marine Science & Oceanography); 483 (Soil Mechanics & Foundations)
61 (PLANT & POWER ENGINEERING); 93 (ENGINEERING PHYSICS); 63 (FLUID DYNAMICS & VACUUM TECHNOLOGY); 47 (OCEAN TECHNOLOGY); 48 (ENGINEERING GEOLOGY)
?t s2/3/all

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03033439 E.I. Monthly No: EI9103031805
Title: Wave-induced breakout of half-buried marine pipes.
Author: Foda, Mostafa; Chang, Y. -H.; Law, Adrian W. -K.
Corporate Source: Univ. of California, Berkeley, CA, USA
Source: Journal of Waterway, Port, Coastal and Ocean Engineering v 116 n 2 Mar-Apr 1990 p 267-286
Publication Year: 1990
CODEN: JWPED5 ISSN: 0733-950X
Language: English

2/3/2
03026061 E.I. Monthly No: EIM9102-008718
Title: Autonomous underwater system for pipeline leak detection and inspection.
Author: Mellin, Torgny A.; Ravik, Olle
Corporate Source: SubOcean, Stockholm, Sweden
Conference Title: Proceedings of the Sixth International Symposium on Unmanned Untethered Submersible Technology Technology
Conference Location: Ellicott City, MD, USA Conference Date: 1989 Jun 12-14
E.I. Conference No.: 14002
Source: Proc Sixth Int Symp Unmmaned Untethered Submersible Technol, Publ by Univ of New Hampshire, Marine Systems Engineering Laboratory, Durham, NH, USA (IEEE cat n 89CH2782-1), p 15-24
Publication Year: 1989
Language: English

2/3/3
03000520 E.I. Monthly No: EIM9012-050429
Title: OTEC seawater pipe cost comparisons.
Author: Jones, Martin E.

Author: Clark, J. I.; Chari, T. R.; Landva, J.; Woodworth-Lynas, C. M. T.
Corporate Source: Cent for Cold Ocean Resources Engineering
Source: Marine Geotechnology v 8 n . 1989 p 51-67
Publication Year: 1989
CODEN: MRGTAY ISSN: 0360-8867
Language: English

2/3/9
02806085 E.I. Monthly No: EIM8910-035305
Title: Interaction between current induced vibrations and scour of pipelines on a sandy bottom.
Author: Kristiansen, O.; Torum, A.
Corporate Source: Norwegian Hydrotechnical Lab, Trondheim, Norw
Conference Title: Proceedings of the Eighth International Conference on Offshore Mechanics and Arctic Engineering - 1989
Conference Location: Hague, Neth Conference Date: 1989 Mar 19-23
E.I. Conference No.: 12374
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium v 5 (of 6). Publ by ASME, New York, NY, USA. p 167-174
Publication Year: 1989
CODEN: PIOSEB
Language: English

2/3/10
02805768 E.I. Monthly No: EIM8910-034988
Title: Wave-induced breakout of half-buried marine pipes.
Author: Foda, Mostafa A.; Law, Adrian W. -K.; Chang, Jo Y. -H.
Corporate Source: Univ of California, Berkeley, CA, USA
Conference Title: Twenty-First Coastal Engineering Conference
Conference Location: Costa del Sol, Malaga, Spain Conference Date: 1988 Jun 20-25
E.I. Conference No.: 12328
Source: Twenty First Coastal Eng Conf v 2. Publ by ASCE, New York, NY, USA. p 1464-1481
Publication Year: 1988
ISBN: 0-87262-687-3
Language: English

2/3/11
02805320 E.I. Monthly No: EIM8910-034540
Title: New seawater delivery systems at the Natural Energy Laboratory of Hawaii.
Author: Daniel, T. H.
Corporate Source: Natural Energy Lab of Hawaii, Kailua-Kona, HI, USA
Conference Title: Solar Engineering 1989 - Proceedings of the Eleventh Annual ASME Solar Energy Conference
Conference Location: San Diego, CA, USA Conference Date: 1989 Apr 2-5
E.I. Conference No.: 12266
Source: American Society of Mechanical Engineers, Solar Energy Division (Publication) SED. Publ by ASME, New York, NY, USA. p 323-330
Publication Year: 1989
CODEN: ASMSE8
Language: English

2/3/12
02792433 E.I. Monthly No: EIM8909-030790
Title: Steep slope seawater supply pipeline.
Author: Lewis, Lloyd F.; Van Ryzin, Joseph; Vega, Luis
Corporate Source: DOE, Washington, DC, USA
Conference Title: Twenty-First Coastal Engineering Conference
Conference Location: Costa del Sol, Malaga, Spain Conference Date: 1988 Jun 20-25
E.I. Conference No.: 12328
Source: Twenty First Costal Eng Conf v 3. Publ by ASCE, New York, NY,

Conference Title: Proceedings of the First International Conference on Ocean Energy Recovery - ICOER'89
Conference Location: Honolulu, HI, USA Conference Date: 1989 Nov 28-30
E.I. Conference No.: 13628
Source: Proc First Int Conf Ocean Energy Recovery ICOER 89. Publ by ASCE, Boston Society of Civil Engineers Sect, Boston, MA, USA. p 297-306
Publication Year: 1989
ISBN: 0-87262-778-0
Language: English

2/3/4
03000519 E.I. Monthly No: EIM9012-050428
Title: OTEC sea water systems technology status.
Author: Vega, L.; Nihous, G.; Lewis, L.; Resnick, A.; Van Ryzin, J.
Corporate Source: Pacific Int Cent for High Technology Research, Honolulu, HI, USA
Conference Title: Proceedings of the First International Conference on Ocean Energy Recovery - ICOER'89
Conference Location: Honolulu, HI, USA Conference Date: 1989 Nov 28-30
E.I. Conference No.: 13628
Source: Proc First Int Conf Ocean Energy Recovery ICOER 89. Publ by ASCE, Boston Society of Civil Engineers Sect, Boston, MA, USA. p 288-296
Publication Year: 1989
ISBN: 0-87262-778-0
Language: English

2/3/5
02992251 E.I. Monthly No: EI9012144474
Title: Marine-crossing sections require extensive surveying.
Author: Yamauchi, Henry M.
Corporate Source: Westcoast Energy Inc, Vancouver, BC, USA
Source: Oil and Gas Journal v 88 n 33 Aug 13 1990 p 47-50
Publication Year: 1990
CODEN: OIGJAV ISSN: 0030-1388
Language: English

2/3/6
02945545 E.I. Monthly No: EIM9008-034282
Title: New design of cold water pipe for use with floating OTEC platforms.
Author: Brown, Martin G.; Hearn, Grant E.; Langley, Robin S.
Corporate Source: Micoperi Offshore Ltd, London, Engl
Conference Title: Oceans '89. Part 1: Fisheries; Global Ocean Studies; Marine Policy & Education; Oceanographic Studies
Conference Location: Seattle, WA, USA Conference Date: 1989 Sep 18-21
E.I. Conference No.: 13274
Source: Oceans 89 Part 1 Fish Global Ocean Stud Mar Policy Educ Oceanogr Stud. Publ by IEEE, IEEE Service Center, Piscataway, NJ, USA. Available from IEEE Service Cent (cat n 89CH2780-3), Piscataway, NJ, USA. p 42-47
Publication Year: 1989
Language: English

2/3/7
02900429 E.I. Monthly No: EI9005055977
Title: Dynamic instability and postflutter vibrations of a pipe string designed for mining manganese nodules in the deep ocean.
Author: Yuan, Shifeng; Aso, Kazuo; Tani, Junji
Source: Nippon Kikai Gakkai Ronbunshu, C Hen/Transactions of the Japan Society of Mechanical Engineers, Part C v 55 n 520 Dec 1989 p 2958-2964
Publication Year: 1989
CODEN: NKCHDB ISSN: 0387-5024
Language: Japanese

2/3/8
02881072 E.I. Monthly No: EI9004044989
Title: Pipeline route selection in an iceberg-scoured seabed.

Publication Year: 1988
ISBN: 0-87262-687-3
Language: English

2/3/13
02785038 E.I. Monthly No: EI8909092019
Title: Combined wave and current forces on large-diameter submarine pipelines.
Author: Andres, Jose M.
Corporate Source: Makai Ocean Engineering Inc, Honolulu, HI, USA
Source: Marine Technology v 26 n 1 Jan 1989 p 23-33
Publication Year: 1989
CODEN: MARTA4 ISSN: 0025-3316
Language: English

2/3/14
02778870 E.I. Monthly No: EI8908076496
Title: World's first rigid free-standing production riser.
Author: Fisher, E. A.; Hackett, H. P.
Corporate Source: Cameron Offshore Eng Inc, Houston, TX, USA
Conference Title: Oceans '88: Proceedings - a Partnership of Marine Interests
Conference Location: Baltimore, MD, USA Conference Date: 1988 Oct 31-Nov 2
E.I. Conference No.: 12139
Source: Oceans '88 Proc Partnership Mar Interest v 2. Publ by IEEE, New York, NY, USA. Available from IEEE Service Cent (cat n 88CH2585-8), Piscataway, NJ, USA. p 607-611
Publication Year: 1988
Language: English

2/3/15
02755078 E.I. Monthly No: EI8907058929
Title: Coastal geomorphology of arctic Alaska.
Author: Barnes, Peter W.; Rawlinson, Stuart E.; Reimnitz, Erk
Corporate Source: US Geological Survey, Menlo Park, CA, USA
Source: Technical Council on Cold Regions Engineering Monograph 1988 p 3-30
Publication Year: 1988
CODEN: TCCME3 ISBN: 0-87262-639-3
Language: English

2/3/16
02726077 E.I. Monthly No: EI8904036310
Title: Three-dimensional scour below pipelines.
Author: Fredsoe, J.; Hansen, E. A.; Mao, Y.; Sumer, B. M.
Corporate Source: Technical Univ of Denmark, Lyngby, Den
Source: Journal of Offshore Mechanics and Arctic Engineering v 110 n 4 Nov 1988 p 373-379
Publication Year: 1988
CODEN: JMOEEX ISSN: 0892-7219
Language: English

2/3/17
02701716 E.I. Monthly No: EI8902014141
Title: Searching through the sewer outfall of San Francisco Bay.
Author: Capone, Vincent J.
Corporate Source: Kaselaan & D'Angelo Associates Inc, USA
Source: Sea Technology v 29 n 8 Aug 1988 p 43-46
Publication Year: 1988
CODEN: SEATAD ISSN: 0093-3651
Language: English

2/3/18
02675543 E.I. Monthly No: EI8811109456
Title: WET CONNECTION SYSTEM OF PIPELINE BUNDLE - SUBSEA PRODUCTION

SYSTEM -.
Author: Miyake, Toshihiro; Kitajima, Taishu; Hagihara, Toshio
Corporate Source: Nippon Steel Corp, Jpn
Source: Nippon Steel Technical Report n 36 Jan 1988 p 15-24
Publication Year: 1988
CODEN: NSTTDI ISSN: 0300-306X
Language: English

2/3/19
02671878 E.I. Monthly No: EI8811108315
Title: MOTIONS OF OTEC PLATFORM IN WAVES AND FORCES ON MOORING CHAIN AND COLD WATER PIPE.
Author: Koterayama, W.; Nakamura, M.; Kyozuka, Y.; Ohkusu, M.; Suhara, T.
Corporate Source: Kyushu Univ, Fukuoka, Jpn
Source: Journal of Offshore Mechanics and Arctic Engineering v 110 n 3 Aug 1988 p 263-271
Publication Year: 1988
CODEN: JMOEEX ISSN: 0892-7219
Language: English

2/3/20
02623697 E.I. Monthly No: EI8808075837
Title: SIMILITUDE ENGINEERING: OCEAN STRUCTURE INTERACTION.
Author: Pranesh, M. R.; Mani, J. S.
Corporate Source: Indian Inst of Technology, Madras, India
Source: Ocean Engineering (Pergamon) v 15 n 2 1988 p 189-200
Publication Year: 1988
CODEN: OCENBQ ISSN: 0029-8018
Language: English

2/3/21
02593975 E.I. Monthly No: EIM8806-032223
Title: CALCULATION OF LONG TERM CUMULATIVE MOVEMENTS FOR SUBMARINE PIPELINES.
Author: Chao, J. C.
Corporate Source: Exxon Production Research Co, Houston, TX, USA
Conference Title: OMAE 1988 Houston, Proceedings of the Seventh International Conference on Offshore Mechanics and Arctic Engineering. Volume V: Pipelines.
Conference Location: Houston, TX, USA Conference Date: 1988 Feb 7-12
E.I. Conference No.: 11083
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 7th. Publ by ASME, New York, NY, USA p 79-86
Publication Year: 1988
CODEN: PIOSEB
Language: English

2/3/22
02593655 E.I. Monthly No: EIM8806-031840
Title: OPEN-CYCLE OTEC SEAWATER EXPERIMENTS IN HAWAII.
Author: Lewis, Lloyd F.; Trimble, Lloyd; Bowers, Janet
Corporate Source: US DOE, Washington, DC, USA
Conference Title: Oceans 87 - Proceedings: The Ocean, An International Workplace.
Conference Location: Halifax, NS, Can Conference Date: 1987 Sep 28-Oct 1
E.I. Conference No.: 10963
Source: Oceans (New York) 1987. Publ by IEEE, New York, NY, USA. Available from IEEE Service Cent (Cat n 87CH2498-4), Piscataway, NJ, USA p 397-402
Publication Year: 1987
CODEN: OCNSDK ISSN: 0197-7385
Language: English

2/3/23

02585761 E.I. Monthly No: EI8806053884
Title: SCIENCE, ENGINEERING AND ECONOMICS: OR AT THE INTERFACE.
Author: Chapman, C. B.
Corporate Source: Univ of Southampton, Engl
Source: Journal of the Operational Research Society v 39 n 1 Jan 1988 p 1-6
Publication Year: 1988
CODEN: JORSDZ ISSN: 0160-5682
Language: English

2/3/24
02580595 E.I. Monthly No: EIM8805-028546
Title: DEVELOPMENT OF A PIPELINE FOR LAND-TYPE OTEC (OCEAN THERMAL ENERGY CONVERSION) PLANT.
Author: Yamada, Y.; Ishibashi, M.; Ota, T.; Shimizu, K.; Ueda, S.
Corporate Source: Tokyo Electric Power Co, Tokyo, Jpn
Conference Title: OMAE 1988 Houston, Proceedings of the Seventh International Conference on Offshore Mechanics and Arctic Engineering.
Conference Location: Houston, TX, USA Conference Date: 1988 Feb 7-12
E.I. Conference No.: 11083
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 7th v 1. Publ by ASME, New York, NY, USA p 111-117
Publication Year: 1988
CODEN: PIOSEB
Language: English

2/3/25
02578693 E.I. Monthly No: EIM8805-026543
Title: FATIGUE INDUCED BY VORTEX SHEDDING ON AN OCEAN PIPELINE.
Author: Aranha, J. A. P.; de Lima, Jairson
Corporate Source: IPT, Sao Paulo, Braz
Conference Title: Offshore Engineering, Volume 5: Proceedings of the 5th International Symposium on Offshore Engineering.
Conference Location: Rio de Janeiro, Braz Conference Date: 1985 Sep 16-20
E.I. Conference No.: 10983
Source: Publ by Pentech Press, London, Engl p 58-89
Publication Year: 1986
ISBN: 0-7273-1505-6
Language: English

2/3/26
02571488 E.I. Monthly No: EI8805046861
Title: OFFSHORE PIPELINES IN EUROPEAN MARITIME AREAS - THE YEARS AHEAD.
Author: Smith, C. J.
Source: Marine Technology/Meerestechnik v 17 n 2 May 1986 p 62-63
Publication Year: 1986
CODEN: MRTKA4 ISSN: 0178-1928
Language: English

2/3/27
02508164 E.I. Monthly No: EI8801006627
Title: FLEXIBLE PIPELINES.
Author: Shekher, Vinod
Source: Mechanical Engineering v 109 n 2 Feb 1987 p 82-83
Publication Year: 1987
CODEN: MEENAH ISSN: 0025-6501
Language: ENGLISH

2/3/28
02359327 E.I. Monthly No: EIM8712-086799
Title: WAVE INDUCED FORCES ON SUBMARINE PIPELINES.
Author: Shankar, N. Jothi; Fatt, Cheong Hin; Subbiah, K.
Corporate Source: Natl Univ of Singapore, Singapore
Conference Title: International Conference on Measuring Techniques of Hydraulics Phenomena in Offshore, Coastal & Inland Waters.
Conference Location: London, Engl Conference Date: 1986 Apr 9-11

E.I. Conference No.: 10156
Source: Publ by BHRA, Cranfield, Engl p 137-148
Publication Year: 1986
ISBN: 0-947711-12-0
Language: English

2/3/29
02331064 E.I. Monthly No: EI8711115017
Title: ON THE STRESS ANALYSIS OF SUSPENDED SUBMARINE PIPELINES.
Author: Ansari, Khyruddin Akbar
Corporate Source: Gonzaga Univ, Spokane, WA, USA
Source: Journal of Pipelines v 6 n 3 Jul 1987 p 273-282
Publication Year: 1987
CODEN: JOPIDT ISSN: 0166-5324
Language: ENGLISH

2/3/30
02327620 E.I. Monthly No: EI8711114855
Title: FIRST OFFSHORE ALASKAN ARCTIC PIPELINES NEARING COMPLETION FOR ENDICOTT FIELD.
Author: Greene, J. A.
Corporate Source: Standard Alaska Production Co, Anchorage, AK, USA
Source: Oil and Gas Journal v 85 n 32 Aug 10 1987 p 33-37, 40
Publication Year: 1987
CODEN: OIGJAV ISSN: 0030-1388
Language: ENGLISH

2/3/31
02318847 E.I. Monthly No: EI8710100911
Title: SEABED SCOUR IS CONTROLLED BY FIBER REINFORCED MATS.
Author: Alsop, Peter
Corporate Source: Seabed Scour Control Systems, Lowestoft, Engl
Source: ipe Line Industry O v 65 n 3 Sep 1986 p 32, 34
Publication Year: 1986
CODEN: PLINAH ISSN: 0032-0145
Language: ENGLISH

2/3/32
02317439 E.I. Monthly No: EI8710105551
Title: LARNACA SEWERAGE AND DRAINAGE SCHEME.
Author: Galbraith, Peter G.
Source: Water and Pollution Control (Don Mills, Canada) v 124 n 6 Oct 1986 p 10-11
Publication Year: 1986
CODEN: WPCOAR ISSN: 0043-1117
Language: ENGLISH

2/3/33
02314875 E.I. Monthly No: EI8709093455
Title: UTILIZATION OF PLASTIC PIPE FOR SUBMARINE OUTFALLS - STATE OF THE ART.
Author: Janson, Lars-Eric
Corporate Source: VBB/SWECO Consulting Group, Stockholm, Swed
Source: Water Science and Technology v 18 n 11 1986, Mar Disp of Wastewater. Proc of an IAWPRC Spec Semin, Rio de Janeiro, Braz, Aug 25-27 1986 p 171-176
Publication Year: 1986
CODEN: WSTED4 ISSN: 0273-1223 ISBN: 0-08-035581-1
Language: ENGLISH

2/3/34
02278149 E.I. Monthly No: EIM8710-067124
Title: WAVE FORCE AND MOVEMENT CALCULATIONS FOR A FLEXIBLE OCEAN OUTFALL PIPELINE.
Author: Pos, J. D.; Russell, K. S.; Zwamborn, J. A.
Corporate Source: CSIR, Stellenbosch, S Afr

Corporate Source: Univ of Stellenbosch, Stellenbosch, S Afr
Conference Title: Twentieth Coastal Engineering Conference, Proceedings of the International Conference.
Conference Location: Taipei, Taiwan Conference Date: 1986 Nov 9-14
E.I. Conference No.: 10127
Source: Proceedings of the Coastal Engineering Conference 20th v 3. Publ by ASCE, New York, NY, USA p 2159-2172
Publication Year: 1987
CODEN: PCECD6 ISBN: 0-87262-600-8
Language: English

2/3/35
02278129 E.I. Monthly No: EIM8710-067104
Title: STABILITY ANALYSIS OF OCEAN PIPELINES: A PROBABILISTIC APPROACH.
Author: Geustyn, Leon C.; Retief, Gideon de F.
Corporate Source: Univ of Stellenbosch, Stellenbosch, S Afr
Conference Title: Twentieth Coastal Engineering Conference, Proceedings of the International Conference.
Conference Location: Taipei, Taiwan Conference Date: 1986 Nov 9-14
E.I. Conference No.: 10127
Source: Proceedings of the Coastal Engineering Conference 20th v 3. Publ by ASCE, New York, NY, USA p 1894-1908
Publication Year: 1987
CODEN: PCECD6 ISBN: 0-87262-600-8
Language: English

2/3/36
02278118 E.I. Monthly No: EIM8710-067093
Title: SCOUR AROUND STRUCTURES.
Author: Bijker, Eco W.
Corporate Source: Delft Univ of Technology, Delft, Neth
Conference Title: Twentieth Coastal Engineering Conference, Proceedings of the International Conference.
Conference Location: Taipei, Taiwan Conference Date: 1986 Nov 9-14
E.I. Conference No.: 10127
Source: Proceedings of the Coastal Engineering Conference 20th v 2. Publ by ASCE, New York, NY, USA p 1754-1768
Publication Year: 1987
CODEN: PCECD6 ISBN: 0-87262-600-8
Language: English

2/3/37
02260992 E.I. Monthly No: EIM8707-047657
Title: UNSOLVED PROBLEMS WITH THE OTEC COLD WATER PIPE.
Author: McHale, F. A.
Corporate Source: Hawaiian Dredging & Construction Co, Honolulu, HI, USA
Conference Title: Proceedings of the Sixth (1987) International Offshore Mechanics and Arctic Engineering Symposium.
Conference Location: Houston, TX, USA Conference Date: 1987 Mar 1-6
E.I. Conference No.: 09552
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 6th v 1. Publ by ASME, New York, NY, USA p 497-500
Publication Year: 1987
CODEN: PIOSEB
Language: English

2/3/38
02250489 E.I. Monthly No: EIM8705-035790
Title: HEAT TRANSFER FROM OFFSHORE PIPELINES WITH VARIOUS COATING MATERIALS.
Author: Kundu, N. K.
Corporate Source: North Texas State Univ, Denton, TX, USA
Conference Title: Pipeline Engineering Symposium - 1987. (Presented at the Tenth Annual Energy-Sources Technology Conference and Exhibition.)
Conference Location: Dallas, TX, USA Conference Date: 1987 Feb 15-18
E.I. Conference No.: 09447
Source: American Society of Mechanical Engineers, Petroleum Division

(Publication) PD v 6, Publ by ASME, New York, NY, USA p 227-231
Publication Year: 1987
CODEN: ASMPEX
Language: English

2/3/39
02243763 E.I. Monthly No: EIM8705-033631
Title: Underwater Robots.
Title: ROBOTY DLA PRAC PODWODNYCH.
Author: Gorkiewicz, Maciej; Tujaka, Andrzej
Corporate Source: Politechniki Szczecinskiej, Szczecin, Pol
Conference Title: I Krajowa Konferencja Robotyki. (Tom 3 - Budowa i Zastosowanie Robotow.)
Conference Location: Wroclaw, Pol Conference Date: 1985 Sep 18-20
E.I. Conference No.: 08093
Source: Prace Naukowe Instytutu Cybernetyki Technicznej, Politechniki Wroclawskiej n 67 1985. Publ by Wydawnictwo Politechniki Wroclawskiej, Wroclaw, Pol p 225-232
Publication Year: 1985
CODEN: PICWDU ISSN: 0324-9794
Language: Polish

2/3/40
02237845 E.I. Monthly No: EIM8703-020975
Title: CONVERSION OF THE SEAWAY PIPELINE FROM OIL TO GAS SERVICE.
Author: Bazin, G. L. II; Ince, R. L. Jr.
Corporate Source: Phillips Petroleum Co, Bartlesville, OK, USA
Conference Title: Facilities, Pipelines, and Measurements: A Workbook for Engineers. (Presented at 41st Petroleum Mechanical Engineering Workshop and Conference.)
Conference Location: Kansas City, MO, USA Conference Date: 1985 Sep 15-17
E.I. Conference No.: 08225
Source: Publ by ASME, New York, NY, USA p 171
Publication Year: 1985
Language: English

2/3/41
02215704 E.I. Monthly No: EI8706061329
Title: SUBSEA PIPELINE PIG TRACKING.
Author: Riddell, R. K.
Corporate Source: Oceano Instruments (UK) Ltd
Source: Underwater Technol v 12 n 4 Winter 1986 p 28-32
Publication Year: 1986
CODEN: UNWTA4
Language: ENGLISH

2/3/42
02213537 E.I. Monthly No: EI8706061320
Title: FORCES EXERTED BY SHALLOW OCEAN WAVES ON A RIGID PIPE SET AT AN ANGLE TO THE FLOW.
Author: Grace, R. A.; Andres, J. M.; Lee, E. K. S.
Corporate Source: Univ of Hawaii at Manoa, Honolulu, HI, USA
Source: Proceedings of the Institution of Civil Engineers (London) v 83 pt 2 Mar 1987 p 43-59
Publication Year: 1987
CODEN: PCIEAT ISSN: 0020-3262
Language: ENGLISH

2/3/43
02211753 E.I. Monthly No: EI8706060771
Title: SPECIAL TOOLING AIDED WORLD'S DEEPEST HOT TAP.
Author: Cooper, Al; Pitman, Robin
Corporate Source: HydroTech Systems
Source: Ocean Industry v 21 n 8 Aug 1986 p 39-40
Publication Year: 1986

Publication Year: 1986
CODEN: OCIDAF ISSN: 0029-8026
Language: ENGLISH

2/3/44
02157721 E.I. Monthly No: EI8701007324
Title: INSTALLING THE 'JUGULAR VEIN' FOR OFFSHORE OIL PRODUCTION.
Author: Stoll, Jeffrey E.
Corporate Source: Surveyor, Paramus, NJ, USA
Source: Surveyor (New York) v 20 n 3 Aug 1986 p 2-10
Publication Year: 1986
CODEN: SRVYAK ISSN: 0039-629X
Language: ENGLISH

2/3/45
02141604 E.I. Monthly No: EIM8612-089570
Title: ARCTIC PIPELINE CONSTRUCTION SIMULTANEOUS TRENCH AND LAY THROUGH LANDFAST ICE.
Author: Healey, A. J.; Roberts, R. A.; Hazlegrove, B. M.
Corporate Source: Brown & Root Int Inc, Houston, TX, USA
Conference Title: Proceedings of the Fifth International Offshore Mechanics and Arctic Engineering (OMAE) Symposium.
Conference Location: Tokyo, Jpn Conference Date: 1986 Apr 13-18
E.I. Conference No.: 08905
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 5th v 4. Publ by ASME, New York, NY, USA p 73-80
Publication Year: 1986
CODEN: PIOSEB
Language: English

2/3/46
02141593 E.I. Monthly No: EIM8612-089559
Title: ADDITIONAL STABILIZATION OF SUBMARINE PIPELINES.
Author: Jinsi, B. K.
Corporate Source: JP Kenny Netherland, The Hague, Neth
Conference Title: Proceedings of the Fifth International Offshore Mechanics and Arctic Engineering (OMAE) Symposium.
Conference Location: Tokyo, Jpn Conference Date: 1986 Apr 13-18
E.I. Conference No.: 08905
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 5th v 3. Publ by ASME, New York, NY, USA p 717-724
Publication Year: 1986
CODEN: PIOSEB
Language: English

2/3/47
02141585 E.I. Monthly No: EIM8612-089551
Title: REVIEW OF FATIGUE ASSESSMENT METHODS FOR PIPE-LAY OPERATIONS.
Author: Jutla, T.; Tubby, P. J.; Giardinieri, V.
Corporate Source: Welding Inst, Cambridge, Engl
Conference Title: Proceedings of the Fifth International Offshore Mechanics and Arctic Engineering (OMAE) Symposium.
Conference Location: Tokyo, Jpn Conference Date: 1986 Apr 13-18
E.I. Conference No.: 08905
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 5th v 3. Publ by ASME, New York, NY, USA p 647-655
Publication Year: 1986
CODEN: PIOSEB
Language: English

2/3/48
02141561 E.I. Monthly No: EIM8612-089527
Title: NONLINEAR FINITE ELEMENT METHOD FOR THE ANALYSIS OF OFFSHORE PIPELINES, RISERS AND CABLE STRUCTURES.
Author: Malahy, R. C.
Corporate Source: RCM, Houston, TX, USA

Conference Title: Proceedings of the Fifth International Offshore Mechanics and Arctic Engineering (OMAE) Symposium.
Conference Location: Tokyo, Jpn Conference Date: 1986 Apr 13-18
E.I. Conference No.: 08905
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 5th v 3. Publ by ASME, New York, NY, USA p 471-478
Publication Year: 1986
CODEN: PIOSEB
Language: English

2/3/49
02141492 E.I. Monthly No: EIM8612-089458
Title: FEASIBILITY AND CONCEPT DESIGN STUDIES FOR OTEC PLANTS ALONG THE EAST COAST OF TAIWAN, REPUBLIC OF CHINA.
Author: Liao, T.; Giannotti, J. G.; Van Mater, P. R. Jr.; Lindman, R. A.
Corporate Source: Taiwan Power Co, Taipei, Taiwan
Conference Title: Proceedings of the Fifth International Offshore Mechanics and Arctic Engineering (OMAE) Symposium.
Conference Location: Tokyo, Jpn Conference Date: 1986 Apr 13-18
E.I. Conference No.: 08905
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 5th v 2. Publ by ASME, New York, NY, USA p 618-625
Publication Year: 1986
CODEN: PIOSEB
Language: English

2/3/50
02141489 E.I. Monthly No: EIM8612-089455
Title: INSTALLATION OF OTEC COLD WATER PIPE IN TOKUNOSHIMA BY SEMI-FLOATING TYPE SUBMARINE METHOD.
Author: Iso, S.; Kondo, I.; Adachi, Y.; Tamamura, F.
Corporate Source: Tokyo Kyuei Co, Tokyo, Jpn
Conference Title: Proceedings of the Fifth International Offshore Mechanics and Arctic Engineering (OMAE) Symposium.
Conference Location: Tokyo, Jpn Conference Date: 1986 Apr 13-18
E.I. Conference No.: 08905
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 5th v 2. Publ by ASME, New York, NY, USA p 599-605
Publication Year: 1986
CODEN: PIOSEB
Language: English

2/3/51
02137020 E.I. Monthly No: EIM8612-084729
Title: HYPERBARIC WELDING HABITATS: ENVIRONMENTAL AND SAFETY ASPECTS.
Author: Lafferty, C. F.
Corporate Source: British Gas Corp, Engl
Conference Title: Developments in Diving Technology, Proceedings of an International Conference, (Divetech '84).
Conference Location: London, Engl Conference Date: 1984 Nov 14-15
E.I. Conference No.: 08310
Source: Publ by Graham & Trotman Ltd (Advances in Underwater Technology and Offshore Engineering, v 1), London, Engl p 63-74
Publication Year: 1985
ISBN: 0-86010-625-X
Language: English

2/3/52
02132489 E.I. Monthly No: EIM8611-079532
Title: SOME PROBLEMS INVOLVING UMBILICALS, CABLES AND PIPES.
Author: Simmonds, D. G.
Corporate Source: RGIT, Aberdeen, Scotl
Conference Title: Offshore and Coastal Modelling. (Papers Presented at the Seventh POLYMODEL Conference.)
Conference Location: Sunderland, Engl Conference Date: 1984 May
E.I. Conference No.: 08159

Studies, v 12), Berlin, West Ger, and New York, NY, USA p 323-352
Publication Year: 1985
ISBN: 0-387-96054-6
Language: English

2/3/53
02122206 E.I. Monthly No: EIM8610-066717
Title: AQUACULTURE USING COLD OTEC WATER.
Author: Daniel, Thomas H.
Corporate Source: Natural Energy Lab of Hawaii, Kailua-Kona, HI, USA
Conference Title: Ocean Engineering and the Environment - Conference Record.
Conference Location: San Diego, CA, USA Conference Date: 1985 Nov 12-14
E.I. Conference No.: 08324
Source: Oceans (New York) 1985. Publ by IEEE, New York, NY, USA. Available from IEEE Service Cent (Cat n 85CH2250-9), Piscataway, NJ, USA p 1284-1289
Publication Year: 1985
CODEN: OCNSDK ISSN: 0197-7385
Language: English

2/3/54
02122105 E.I. Monthly No: EIM8610-066616
Title: FIELD PERFORMANCE OF THE BENIGRAPH HIGH-RESOLUTION MULTIBEAM SEAFLOOR MAPPING SYSTEM.
Author: Hammerstad, Erik; Lovik, Arne; Minde, Svein; Krane, Leif; Steinset, Magne
Corporate Source: Bentech A/S, Tromso, Norw
Conference Title: Ocean Engineering and the Environment - Conference Record.
Conference Location: San Diego, CA, USA Conference Date: 1985 Nov 12-14
E.I. Conference No.: 08324
Source: Oceans (New York) 1985. Publ by IEEE, New York, NY, USA. Available from IEEE Service Cent (Cat n 85CH2250-9), Piscataway, NJ, USA p 682-685
Publication Year: 1985
CODEN: OCNSDK ISSN: 0197-7385
Language: English

2/3/55
02119543 E.I. Monthly No: EIM8609-062565
Title: STATICS AND DYNAMICS OF PIPELINE SPANS.
Author: Lapidaire, P. J. M.
Corporate Source: Delft Univ of Technology, Delft, Neth
Conference Title: Behaviour of Offshore Structures, Proceedings of the 4th International Conference.
Conference Location: Delft, Neth Conference Date: 1985 Jul 1-5
E.I. Conference No.: 08202
Source: Publ by Elsevier Science Publishers BV (Developments in Marine Technology, v 2), Amsterdam, Neth and New York, NY, USA p 729-738
Publication Year: 1985
ISBN: 0-444-42513-6
Language: English

2/3/56
02119542 E.I. Monthly No: EIM8609-062564
Title: NATURAL SELF-BURIAL OF SUBMARINE PIPELINES.
Author: Leeuwestein, W.; Bijker, E. W.; Peerbolte, E. B.; Wind, H. G.
Corporate Source: Delft Univ of Technology, Delft, Neth
Conference Title: Behaviour of Offshore Structures, Proceedings of the 4th International Conference.
Conference Location: Delft, Neth Conference Date: 1985 Jul 1-5
E.I. Conference No.: 08202
Source: Publ by Elsevier Science Publishers BV (Developments in Marine Technology, v 2), Amsterdam, Neth and New York, NY, USA p 717-728

Publication Year: 1985
ISBN: 0-444-42513-6
Language: English

2/3/57
02118624 E.I. Monthly No: EIM8609-061646
Title: INTERNAL CORROSION PROTECTION FOR WASTEWATER SYSTEM, PERTH, WESTERN AUSTRALIA.
Author: Wishart, S. J.; McLeanie, D. D.
Corporate Source: Binnie & Partners, London, Engl
Conference Title: Plastics for Pipeline Renovation and Corrosion Protection in UK and Overseas.
Conference Location: London, Engl Conference Date: 1985 Mar 27-28
E.I. Conference No.: 08215
Source: Publ by Plastics & Rubber Inst, London, Engl p 10.1-10.14
Publication Year: 1985
Language: English

2/3/58
02100136 E.I. Monthly No: EIM8607-042070
Title: STM4-120 STIRLING ENGINE FOR UNDERWATER APPLICATION.
Author: Meijer, Roelf J.; Ziph, Benjamin; Godett, Ted M.
Corporate Source: Stirling Thermal Motors Inc, Ann Arbor, MI, USA
Conference Title: Proceedings of the 20th Intersociety Energy Conversion Engineering Conference, Energy for the Twenty-First Century. (Volume 3.)
Conference Location: Miami Beach, FL, USA Conference Date: 1985 Aug 18-23
E.I. Conference No.: 07916
Source: Proceedings of the Intersociety Energy Conversion Engineering Conference 20th. Publ by SAE (P-164), Warrendale, PA, USA. Also available from IEEE Service Cent (Cat n 85CH2242-6), Piscataway, NJ, USA p 278-281
Publication Year: 1985
CODEN: PIECDE ISSN: 0146-955X ISBN: 0-89883-725-1
Language: English

2/3/59
02067119 E.I. Monthly No: EIM8601-004382
Title: ECONOMIC AND TECHNICAL EVALUATION OF SLURRY PIPELINE TRANSPORT TECHNIQUES IN THE INTERNATIONAL COAL TRADE.
Author: Brookes, D. A.; Dodwell, C. H.
Corporate Source: BP, Business Technical Support Dep, London, Engl
Conference Title: Proceedings of the Tenth International Conference on Slurry Technology.
Conference Location: Lake Tahoe, NV, USA Conference Date: 1985 Mar 26-28
E.I. Conference No.: 07368
Source: Publ by Slurry Technology Assoc, Washington, DC, USA p 67-83
Publication Year: 1985
ISBN: 0-932066-10-0
Language: English

2/3/60
02056246 E.I. Monthly No: EI8612124831 E.I. Yearly No: EI86077229
Title: World Natural Gas Economy: Logic of Supply and Constraints of Demand.
Title: L'ECONOMIE MONDIALE DU GAZ NATUREL: LOGIQUES D'OFFRE ET CONTRAINTES DE DEMANDE.
Author: Benzoni, Laurent
Corporate Source: Univ Paris XIII, Fr
Source: Revue de l'Energie v 36 n 378 Nov 1985 p 457-466
Publication Year: 1985
CODEN: REENDZ ISSN: 0303-240X
Language: FRENCH

2/3/61
02039883 E.I. Monthly No: EI8611113044 E.I. Yearly No: EI86087811

Title: DYNAMICAL STABILITY OF ARTICULATED PIPE IN THE OCEAN.
Author: Kawashima, Takeshi; Shimogo, Taro
Source: Nippon Kikai Gakkai Ronbunshu, C Hen v 51 n 467 Jul 1985 p 1778-1785
Publication Year: 1985
CODEN: NKCHDB ISSN: 0387-5024
Language: JAPANESE

2/3/62
02035120 E.I. Monthly No: EI8611113048 E.I. Yearly No: EI86087854
Title: HOW AN ROV-PLACED GROUT BAG CORRECTED A SEABED FREE SPAN.
Author: Sandford, A. J.
Corporate Source: Stolt-Nielsen Seaway Technology Ltd, Aberdeen, Scotl
Source: ipe Line Industry O v 64 n 6 Jun 1986 p 26-27
Publication Year: 1986
CODEN: PLINAH ISSN: 0032-0145
Language: ENGLISH

2/3/63
02001736 E.I. Monthly No: EI8608075526 E.I. Yearly No: EI86087780
Title: OPERATION PLUTO.
Author: Middleton, E. W.
Source: Pipes and Pipelines International v 13 n 2 Apr 1986 p 27-29
Publication Year: 1986
CODEN: PPIIAU ISSN: 0370-1204
Language: ENGLISH

2/3/64
01986843 E.I. Monthly No: EI8607062834 E.I. Yearly No: EI86086081
Title: STATPIPE LANDFALL APPROACH SOLVES ROCKY SHORE PROBLEMS.
Author: Lund, Sverre; Gjertveit, Erling
Corporate Source: Den Norske Stats Oljeselskap A/S, Stavanger, Norw
Source: Oil and Gas Journal v 84 n 19 May 12 1986 p 67-68
Publication Year: 1986
CODEN: OIGJAV ISSN: 0030-1388
Language: ENGLISH

2/3/65
01986801 E.I. Monthly No: EI8607062831 E.I. Yearly No: EI86086058
Title: STATPIPE EXPERIENCE REVEALS TECHNIQUES FOR SEABED PROBLEMS.
Author: Lund, Sverre; Gjertveit, Erling
Corporate Source: Statoil, Stavanger, Norw
Source: Oil and Gas Journal v 84 n 17 Apr 28 1986 p 57-62
Publication Year: 1986
CODEN: OIGJAV ISSN: 0030-1388
Language: ENGLISH

2/3/66
01971665 E.I. Monthly No: EI8605041246 E.I. Yearly No: EI86080367
Title: HYDRAULICALLY POWERED BULLDOZER WORKS IN SUBSEA LOCATIONS.
Author: Anon
Source: Pipe Line Industry v 63 n 6 Dec 1985 p 31
Publication Year: 1985
CODEN: PLINAH ISSN: 0032-0145
Language: ENGLISH

2/3/67
01968926 E.I. Monthly No: EI8605041785 I. Yearly No: EI86087776
Title: HYDROMECHANICS OF SUBMARINE PIPELI. S: DESIGN PROBLEMS.
Author: Herbich, John B.
Corporate Source: Texas A&M Univ, College Station, TX, USA
Source: Canadian Journal of Civil Engineering v 12 n 4 Dec 1985 p 863-874
Publication Year: 1985
CODEN: CJCEB8 ISSN: 0315-1468
Language: ENGLISH

2/3/68
01960718 E.I. Monthly No: EI8604032450 E.I. Yearly No: EI86087774
Title: DYNAMIC BEHAVIOR OF DEEP-OCEAN PIPELINE.
Author: Zimmerman, Michael; Hudspeth, Robert; Leonard, John; Tedesco, Joe ; Borgman, Leon
Corporate Source: Standard Oil of California, San Francisco, CA, USA
Source: Journal of Waterway, Port, Coastal and Ocean Engineering v 112 n 2 Mar 1986 p 183-199
Publication Year: 1986
CODEN: JWPED5 ISSN: 0733-950X
Language: ENGLISH

2/3/69
01933606 E.I. Monthly No: EI8601005876 E.I. Yearly No: EI86087770
Title: FREE SPAN VIBRATIONS OF SUBMARINE PIPELINES IN STEADY FLOWS - EFFECT OF FREE-STREAM TURBULENCE ON MEAN DRAG COEFFICIENTS.
Author: TORUM, A.; ANAND, N. M.
Corporate Source: NORWEGIAN INST OF TECHNOLOGY, DIV OF PORT & OCEAN ENGINEERING, TRONDHEIM, NORW
Source: J ENERGY RESOUR TECHNOL TRANS ASME V 107 N 4 DEC 1985 P 415-420
Publication Year: 1985
CODEN: JERTD2 ISSN: 0195-0738
Language: ENGLISH

2/3/70
01898638 E.I. Monthly No: EIM8510-061326
Title: PROCEDURES FOR DESIGN OF OFFSHORE PIPELINES TRAVERSING SLOPE AREAS SUBJECT TO SEISMIC AND/OR OCEAN WAVE EXCITATION.
Author: Kistler, E. L.
Corporate Source: Ernest L. Kistler & Associates, Shreveport, LA, USA
Conference Title: Proceedings of the 1985 Pressure Vessels and Piping Conference. (Seismic Performance of Pipelines and Storage Tanks.)
Conference Location: New Orleans, LA, USA Conference Date: 1985 Jun 23-26
E.I. Conference No.: 06710
Source: American Society of Mechanical Engineers, Pressure Vessels and Piping Division (Publication) PVP v 98-4. Publ by ASME, New York, NY, USA p 95-108
Publication Year: 1985
CODEN: AMPPD5 ISSN: 0277-027X
Language: English

2/3/71
01878279 E.I. Monthly No: EIM8506-036108
Title: TIME AND FREQUENCY LOADING ANALYSIS OF SUBMARINE PIPELINES.
Author: Alexander, H. C.; Allen, P. L.; Warner, J. L.
Corporate Source: California State Univ, Long Beach, Long Beach, CA, USA
Conference Title: Nineteenth Coastal Engineering Conference, Proceedings of the International Conference.
Conference Location: Houston, TX, USA Conference Date: 1984 Sep 3-7
E.I. Conference No.: 06520
Source: Proceedings of the Coastal Engineering Conference 19th v 3. Publ by ASCE, New York, NY, USA p 2726-2736
Publication Year: 1985
CODEN: PCECD6 ISBN: 0-87262-438-2
Language: English

2/3/72
01878218 E.I. Monthly No: EIM8506-036047
Title: SHORE APPROACH AT THE DANISH NORTH SEA COAST, MONITORING OF SEDIMENTATION IN A DREDGED TRENCH.
Author: Mangor, Karsten; Sorensen, Torben; Navntoft, Erling
Corporate Source: Danish Hydraulic Inst, Horsholm, Den
Conference Title: Nineteenth Coastal Engineering Conference, Proceedings of the International Conference.
Conference Location: Houston, TX, USA Conference Date: 1984 Sep 3-7

E.I. Conference No.: 06520
Source: Proceedings of the Coastal Engineering Conference 19th v 2. Publ by ASCE, New York, NY, USA p 1816-1829
Publication Year: 1985
CODEN: PCECD6 ISBN: 0-87262-438-2
Language: English

2/3/73
01876856 E.I. Monthly No: EIM8506-034464
Title: OPTIMUM DESIGN OF SUBMARINE SUSPENDED PIPELINES.
Author: Huang, Z.; Seireg, A.
Corporate Source: Research Inst of Petroleum Exploration & Development, Beijing, China
Conference Title: Proceedings of the Fourth International Offshore Mechanics and Arctic Engineering Symposium. (Presented at the 1985 ASME Energy-Sources Technology Conference & Exhibition.)
Conference Location: Dallas, TX, USA Conference Date: 1985 Feb 17-21
E.I. Conference No.: 06296
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 4th v 1. Publ by ASME, New York, NY, USA p 695-702
Publication Year: 1985
CODEN: PIOSEB
Language: English

2/3/74
01876849 E.I. Monthly No: EIM8506-034457
Title: FREE SPAN VIBRATIONS OF SUBMARINE PIPELINES IN STEADY FLOWS-EFFECT OF FREE STREAM TURBULENCE ON MEAN DRAG COEFFICIENTS.
Author: Torum, A.; Anand, N. M.
Corporate Source: Univ of Trodheim, Div of Port & Ocean Engineering, Trondheim, Norw
Conference Title: Proceedings of the Fourth International Offshore Mechanics and Arctic Engineering Symposium. (Presented at the 1985 ASME Energy-Sources Technology Conference & Exhibition.)
Conference Location: Dallas, TX, USA Conference Date: 1985 Feb 17-21
E.I. Conference No.: 06296
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 4th v 1. Publ by ASME, New York, NY, USA p 629-639
Publication Year: 1985
CODEN: PIOSEB
Language: English

2/3/75
01876842 E.I. Monthly No: EIM8506-034450
Title: SCOUR AROUND PIPELINES UNDER MARINE ENVIRONMENT.
Author: Nalluri, C.; Ibrahim, A.
Corporate Source: Univ of Newcastle upon Tyne, Dep of Civil Engineering, Newcastle upon Tyne, Engl
Conference Title: Proceedings of the Fourth International Offshore Mechanics and Arctic Engineering Symposium. (Presented at the 1985 ASME Energy-Sources Technology Conference & Exhibition.)
Conference Location: Dallas, TX, USA Conference Date: 1985 Feb 17-21
E.I. Conference No.: 06296
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 4th v 1. Publ by ASME, New York, NY, USA p 569-575
Publication Year: 1985
CODEN: PIOSEB
Language: English

2/3/76
01876838 E.I. Monthly No: EIM8506-034446
Title: CRITICAL REVIEW OF NEAR BOTTOM BOUNDARY LAYER MODELS WITH SPECIAL ATTENTION TO STABILITY OF MARINE PIPELINES.
Author: Deigaard, R.; Jacobsen, V.; Bryndum, M. B.
Corporate Source: Danish Hydraulic Inst, Horsholm, Den
Conference Title: Proceedings of the Fourth International Offshore

Mechanics and Arctic Engineering Symposium. (Presented at the 1985 ASME Energy-Sources Technology Conference & Exhibition.)
Conference Location: Dallas, TX, USA Conference Date: 1985 Feb 17-21
E.I. Conference No.: 06296
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 4th v 1. Publ by ASME, New York, NY, USA p 542-549
Publication Year: 1985
CODEN: PIOSEB
Language: English

2/3/77
01876822 E.I. Monthly No: EIM8506-034430
Title: DYNAMICS OF A PIPE ASPIRATING FLUID SUCH AS MIGHT BE USED IN OCEAN MINING.
Author: Paidoussis, M. P.; Luu, T. P.
Corporate Source: McGill Univ, Dep of Mechanical Engineering, Montreal, Que, Can
Conference Title: Proceedings of the Fourth International Offshore Mechanics and Arctic Engineering Symposium. (Presented at the 1985 ASME Energy-Sources Technology Conference & Exhibition.)
Conference Location: Dallas, TX, USA Conference Date: 1985 Feb 17-21
E.I. Conference No.: 06296
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 4th v 1. Publ by ASME, New York, NY, USA p 391-397
Publication Year: 1985
CODEN: PIOSEB
Language: English

2/3/78
01876777 E.I. Monthly No: EIM8506-034385
Title: PROCEEDINGS OF THE FOURTH INTERNATIONAL OFFSHORE MECHANICS AND ARCTIC ENGINEERING SYMPOSIUM.
Author: Chung, Jin S. (Ed.); Lunardini, Virgil J. (Ed.); Chakrabarti, S. K. (Ed.); Wang, Y. S. (Ed.); Sodhi, D. S. (Ed.); Karal, K. (Ed.)
Corporate Source: Colorado Sch of Mines, Golden, CO, USA
Conference Title: Proceedings of the Fourth International Offshore Mechanics and Arctic Engineering Symposium. (Presented at the 1985 ASME Energy-Sources Technology Conference & Exhibition.)
Conference Location: Dallas, TX, USA Conference Date: 1985 Feb 17-21
E.I. Conference No.: 06296
Source: Proceedings of the International Offshore Mechanics and Arctic Engineering Symposium 4th. Publ by ASME, New York, NY, USA 2 vol. 1380p
Publication Year: 1985
CODEN: PIOSEB
Language: English

2/3/79
01840482 E.I. Monthly No: EI8512121446 E.I. Yearly No: EI85083916
Title: SINKING BEHAVIOR OF PIPE WITH WATER-INFLOW.
Author: Kawashima, Takeshi; Shimogo, Taro
Corporate Source: Keio Univ, Dep of Mechanical Engineering, Yokohama, Jpn
Source: Bulletin of the JSME v 28 n 245 Nov 1985 p 2796-2803
Publication Year: 1985
CODEN: BJSEA8 ISSN: 0021-3764
Language: ENGLISH

2/3/80
01836940 E.I. Monthly No: EI8512123898 E.I. Yearly No: EI85103687
Title: SAN FRANCISCO OUTFALL: THE CHAMP?
Author: Murphy, G. J.; Eisenberg, Y.
Corporate Source: Parsons Brinckerhoff, San Francisco, CA, USA
Source: Civil Engineering (New York) v 55 n 12 Dec 1985 p 58-61
Publication Year: 1985
CODEN: CIEGAG ISSN: 0009-7853
Language: ENGLISH

2/3/81
01829466 E.I. Monthly No: EI8512121489 E.I. Yearly No: EI85084159
Title: OPTIMUM DESIGN OF SUBMARINE SUSPENDED PIPELINES.
Author: Huang, Z.; Seireg, A.
Corporate Source: Research Inst of Petroleum Exploration & Development, Beijing, China
Source: Journal of Energy Resources Technology, Transactions of the ASME v 107 n 3 Sep 1985 p 335-341
Publication Year: 1985
CODEN: JERTD2 ISSN: 0195-0738
Language: ENGLISH

2/3/82
01827911 E.I. Monthly No: EI8511108906 E.I. Yearly No: EI85103689
Title: INVESTIGATION, DESIGN AND CONSTRUCTION OF SUBMARINE OCEAN OUTFALL PIPELINE OFF NINETY MILE BEACH, GIPPSLAND, VICTORIA, AUSTRALIA.
Author: Ryan, J. J.
Corporate Source: Gutteridge Haskins & Davey Consulting Engineers, Brisbane, Aust
Source: Water Science and Technology v 17 n 8 pt 4 1985 p 1465-1467
Publication Year: 1985
CODEN: WSTED4 ISSN: 0273-1223
Language: ENGLISH

2/3/83
01801010 E.I. Monthly No: EI8509080894 E.I. Yearly No: EI85077746
Title: ENGINEERS TRYING NEW APPROACH TO ARCTIC CONSTRUCTION, PRODUCTION, AND TRANSPORTATION.
Author: Anon
Source: Oil and Gas Journal v 83 n 31 Aug 5 1985 p 76-79
Publication Year: 1985
CODEN: OIGJAV ISSN: 0030-1388
Language: ENGLISH

2/3/84
01801008 E.I. Monthly No: EI8509081313 E.I. Yearly No: EI85082341
Title: CANADIAN ARCTIC PRODUCTION PROSPECTS BRIGHTEN.
Author: Anon
Source: Oil and Gas Journal v 83 n 31 Aug 5 1985 p 57-60
Publication Year: 1985
CODEN: OIGJAV ISSN: 0030-1388
Language: ENGLISH

2/3/85
01772[illegible] E.I. Monthly No: EI8507058825 E.I. Yearly No: EI85084152
Title: [illegible]MICS OF A PIPE ASPIRATING FLUID SUCH AS MIGHT BE USED IN OCEAN MINING
Author: Paidoussis, M. P.; Luu, T. P.
Corporate Source: McGill Univ, Dep of Mechanical Engineering, Montreal, Que, Can
Source: Journal of Energy Resources Technology, Transactions of the ASME v 107 n 2 Jun 1985 p 250-255
Publication Year: 1985
CODEN: JERTD2 ISSN: 0195-0738
Language: ENGLISH

2/3/86
01771790 E.I. Monthly No: EI8507058824 E.I. Yearly No: EI85084151
Title: CONCEPT FOR DESIGN OF SUBMARINE PIPELINES TO RESIST OCEAN FORCES.
Author: Karal, K.
Corporate Source: Norges Tekniske Hogskole, Trondheim, Norw
Source: Journal of Energy Resources Technology, Transactions of the ASME v 107 n 1 Mar 1985 p 42-47
Publication Year: 1985
CODEN: JERTD2 ISSN: 0195-0738
Language: ENGLISH

2/3/87
01763242 E.I. Monthly No: EI8506048758 E.I. Yearly No: EI85084148
Title: SINKING BEHAVIOR OF PIPELINE IN THE OCEAN.
Author: Kawashima, Takeshi; Shimogo, Taro
Corporate Source: Keio Univ, Dep of Mechanical Engineering, Yokohama, Jpn
Source: Bulletin of the JSME v 28 n 237 Mar 1985 p 508-514
Publication Year: 1985
CODEN: BJSEA8 ISSN: 0021-3764
Language: ENGLISH

2/3/88
01761909 E.I. Monthly No: EI8506048600 E.I. Yearly No: EI85082246
Title: WAVE-INDUCED FORCES ON BURIED PIPELINES.
Author: Lennon, Gerard P.
Corporate Source: Lehigh Univ, Dep of Civil Engineering, Bethlehem, PA, USA
Source: Journal of Waterway, Port, Coastal and Ocean Engineering v 111 n 3 May 1985 p 511-524
Publication Year: 1985
CODEN: JWPED5
Language: ENGLISH

2/3/89
01761770 E.I. Monthly No: EI8506048599 E.I. Yearly No: EI85082245
Title: WAVE LOAD-SUBMARINE PIPELINE-SEAFLOOR INTERACTION.
Author: Pranesh, M. R.; Somanatha, G. S.
Corporate Source: Indian Inst of Technology, Ocean Engineering Cent, Madras, India
Source: Journal of Transportation Engineering v 111 n 3 May 1985 p 237-250
Publication Year: 1985
CODEN: JTPEDI
Language: ENGLISH

2/3/90
01755815 E.I. Monthly No: EI8505039358 E.I. Yearly No: EI85083937
Title: LARGE BENDING OF PIPES.
Author: Sohal, I. S.; Chen, W. F.
Corporate Source: Purdue Univ, Sch of Civil Engineering, West Lafayette, IN, USA
Source: Engineering Structures v 7 n 2 Apr 1985 p 121-130
Publication Year: 1985
CODEN: ENSTDF ISSN: 0141-0296 ISBN: 0-13-782178-6
Language: ENGLISH

2/3/91
01746467 E.I. Monthly No: EI8504029971 E.I. Yearly No: EI85078114
Title: TEXACO'S HIGHLANDER FIELD DEVELOPED SUBSEA.
Author: Bleakley, W. B.
Corporate Source: Petroleum Engineer Int, Dallas, TX, USA
Source: Petroleum Engineer International v 57 n 2 Feb 1985 4p between p 24 and 32
Publication Year: 1985
CODEN: PENGA6 ISSN: 0164-8322 ISBN: 0-89520-421-5
Language: ENGLISH
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2/3/1
91-01233
Hydrodynamic forces on seabed pipelines
Verley, R.L.P.; Lambrakos, K.F.; Reed, K.
Statoil, Postuttak, 7004 Trondheim, Norway
Ocean Technology Conf. Houston, TX (USA) 27-30 Apr 1987
J. WATERWAY PORT COAST. OCEAN ENG VOL. 115, NO. 2, pp. 190-204, 1989
SUMMARY LANGUAGE - ENGLISH

2/3/2
91-01214
The effect of the sea-bottom proximity on the hydrodynamic forces for submarine pipelines
E, Xuequan; Li, Zhanhua; Ling, Guocan
Inst. Mech., Acad. Sinica, Beijing, People's Rep. China
THE OCEAN ENG./HAIYANG GONGCHENG VOL. 7, NO. 1, pp. 90-100, 1989
SUMMARY LANGUAGE - ENGLISH

2/3/3
89-07753
Combined wave and current boundary layer model for fixed rough seabeds
Myrhaug, D.; Slaattelid, O.H.
Div. Mar. Hydrodyn., Norwegian Inst. Technol., N-7034 Trondheim-NTH, Norway
OCEAN ENG VOL. 16, NO. 2, pp. 119-142, 1989
SUMMARY LANGUAGE - ENGLISH

2/3/4
89-06565
Seismic response of buried submarine pipelines
Datta, T.K.; Mashaly, E.A.
Dep. Civ. Eng., Indian Inst. Technol., Delhi, Hauz-Khas, New Delhi, India
J. ENERGY RESOUR. TECHNOL VOL. 110, NO. 4, pp. 208-219, 1988
SUMMARY LANGUAGE - ENGLISH

2/3/5
89-04848
Vortex-shedding response of long cylindrical structures in shear flow
Wang, E.; Whitney, A.K.; Nikkel, K.G.
Lockheed Missiles and Space Co., Inc., Sunnyvale, CA 94086, USA
5. International Symposium and Exhibit on Offshore Mechanics and Arctic Engineering Tokyo (Japan) 13-22 Apr 1986
J. OFFSHORE MECH. ARCT. ENG VOL. 110, NO. 1, pp. 24-31, 1988
SUMMARY LANGUAGE - ENGLISH

2/3/6
89-04814
Cameron introduces space age titanium to the subsea
Anon.
SEA TECHNOL VOL. 29, NO. 6, pp. 39-40, 1988

2/3/7
89-04572
Wastewater management for coastal cities: The ocean disposal option
Gunnerson, C.G.
International Bank for Reconstruction and Development, Washington, DC (USA)
TECH. PAP. WORLD BANK NO. 77, 1988
SUMMARY LANGUAGE - ENGLISH; NTIS Order No.: PB88-170741/GAR. ISBN 0-8213-0989-7.

2/3/8
89-03231
Acoustics in control for Balmoral pipelines
Anon.
OFFSHORE ENG p. 55, 1986

2/3/9
89-03054
Thermal buckling of offshore pipelines
Ju, G.T.; Kyriakides, S.
Eng. Mech. Res. Lab., Dep. Aerosp. Eng. and Eng. Mech , Univ. Texas, Austin, TX 78712, USA
J. OFFSHORE MECH. ARCT. ENG VOL. 110, NO. 4, pp. 355-364, 1988
SUMMARY LANGUAGE - ENGLISH

2/3/10
89-03030
On the analysis of pipeline during laying operation.; Haidi guanxian puguan zuoye zhuangtai fenxi
Gu, Yongning
Shanghai Jiaotong Univ., Shanghai, People's Rep. China
THE OCEAN ENG./HAIYANG GONGCHENG VOL. 6, NO. 2, pp. 11-23, 1988
SUMMARY LANGUAGE - ENGLISH

2/3/11
89-03028
Discussion on the limit erosion length of the ocean oil and gas pipeline.; Haiyang youqi guandao jixian chongshua changdu de tantao
Yuan, Xiangzhong; Zheng, Liang
Southwestern Pet. Inst., People's Rep. China
THE OCEAN ENG./HAIYANG GONGCHENG VOL. 6, NO. 2, pp. 1-10, 1988
SUMMARY LANGUAGE - ENGLISH

2/3/12
89-01382
PIPESTAB project: Improved design basis for submarine pipeline stability
Wolfram, W.R.,Jr.; Getz, J.R.; Verley, R.L.P.
Exxon Production Research Co., USA
Offshore Technology Conf., Houston, TX (USA)
19. Annual Offshore Technology Conference Houston, TX (USA) 27-30 Apr 1987
NINETEENTH ANNUAL OFFSHORE TECHNOLOGY CONFERENCE. 1987 PROCEEDINGS pp. 153-158, 1987
OTC, HOUSTON, TX (USA)
PROC. OFFSHORE TECHNOL. CONF., . . ; SUMMARY LANGUAGE - ENGLISH; OTC-5501.

2/3/13
89-01087
Stress analysis of marine pipelines crossing elevated obstructions or

lowered depressions at seabed
Zhu, Fugen
Dep. Nav. Architect. and Ocean Eng., Shanghai Jiaotong Univ., Shanghai, People's Rep. China
CHINA OCEAN ENG VOL. 1, NO. 4, pp. 109-116, 1987
SUMMARY LANGUAGE - ENGLISH

2/3/14
88-05982
Wave induced forces on submarine pipelines
Shankar, N.J.; Fatt, C.H.; Subbiah, K.; Pounsford, J.H. (ed.)
Dep. Civ. Eng., Natl. Univ. Singapore, Kent Ridge, Singapore 0511, Singapore
BHRA, The Fluid Engineering Centre, Bedford (UK)
Int. Conf. on Measuring Techniques of Hydraulics Phenomena in Offshore, Coastal and Inland Waters London (UK) 9-11 Apr 1986
INTERNATIONAL CONFERENCE ON MEASURING TECHNIQUES OF HYDRAULICS PHENOMENA IN OFFSHORE, COASTAL AND INLAND WATERS LONDON, ENGLAND: 9-11 APRIL, 1986 pp. 137-148, 1986
BHRA, THE FLUID ENGINEERING CENT., BEDFORD (UK)
SUMMARY LANGUAGE - ENGLISH

2/3/15
88-05613
Wave-induced forces on buried pipelines
McDougal, W.G.; Davidson, S.H.; Monkmeyer, P.L.; Sollitt, C.K.
Ocean Eng. Program, Dep. Civ. Eng., Oregon State Univ., Corvallis, OR 97331, USA
J. WATERWAY PORT COAST. OCEAN ENG VOL. 114, NO. 2, pp. 220-236, 1988
SUMMARY LANGUAGE - ENGLISH

2/3/16
88-04334
Simplex provides flexible pipe Offshore Petroleum Delivery System (OPDS) to the U.S. Navy
Dubois, B.C.
Simplex Wire and Cable Co., USA
Marine Technology Soc., Washington, DC (USA); IEEE Ocean Eng. Soc., NY (USA)
Oceans '85 "Engineering and the Environment" San Diego, CA (USA) 12-14 Nov 1985
OCEANS '85 PROCEEDINGS: OCEAN ENGINEERING AND THE ENVIRONMENT VOL. 2. pp. 1244-1252, 1985
OCEANS '85, , , : SUMMARY LANGUAGE - ENGLISH

2/3/17
88-04163
Offshore oil and gas technology assessment
Otteman, L.G.; Crooke, R.C.; Shoemaker, R.
Shell California Product., Inc., CA, USA
Marine Technology Soc., Washington, DC (USA); IEEE Ocean Eng. Soc., NY (USA)
Oceans '85 "Engineering and the Environment" San Diego, CA (USA) 12-14 Nov 1985
OCEANS '85 PROCEEDINGS: OCEAN ENGINEERING AND THE ENVIRONMENT VOL. 1. pp. 4-16, 1985
OCEANS '85, , , : SUMMARY LANGUAGE - ENGLISH

2/3/18
88-03838
Ice gouge hazard analysis
Lanan, G.A.; Niedoroda, A.W.; Weeks, W.F.
Offshore Technology Conf., Houston, TX (USA)
18. Annual Offshore Technology Conference Houston, TX (USA) 5-8 May 1986
EIGHTEENTH ANNUAL OFFSHORE TECHNOLOGY CONFERENCE, 1986 PROCEEDINGS pp.

87-66, 1986
OTC, HOUSTON, TX (USA)
PROC. OFFSHORE TECHNOL. CONF., , , ; SUMMARY LANGUAGE - ENGLISH; OTC 5298.

2/3/19
87-01430
Operational experience with the cold water pipe at the Natural Energy Laboratory of Hawaii
Daniel, T.H.
Natural Energy Lab. of Hawaii, P.O. Box 1749, Kailua-Kona, HI 96745, USA
Marine Technology Soc., Washington, DC (USA); IEEE, New York, NY (USA)
Oceans '86 "Science-Engineering-Adventure" Washington, DC (USA) 22-25 Sep 1986
OCEANS '86 CONFERENCE RECORD: SCIENCE-ENGINEERING-ADVENTURE. VOL. 1. SYSTEMS, STRUCTURES AND ANALYSIS pp. 185-190, 1986
IEEE PUBLISHING SERV., NEW YORK, NY (USA)
OCEANS '86, , , : SUMMARY LANGUAGE - ENGLISH

2/3/20
87-01321
Wave induced forces on submarine pipelines
Shankar, N.J.; Subbiah, K.
Dep. Civ. Eng., Natl. Univ. Singapore, Kent Ridge 0511, Singapore
BHRA, Fluid Engineering Center, London (UK)
International Conference on Measuring Techniques of Hydraulics Phenomena in Offshore, Coastal and Inland Waters London (UK) 9-11 Apr 1986
PAPERS PRESENTED AT THE INTERNATIONAL CONFERENCE ON MEASURING TECHNIQUES OF HYDRAULICS PHENOMENA IN OFFSHORE, COASTAL AND INLAND WATERS. LONDON, ENGLAND: 9-11 APRIL, 1986 pp. 137-148, 1986
BHRA, FLUID ENGINEERING CENT., BEDFORD (UK)
SUMMARY LANGUAGE - ENGLISH

2/3/21
86-06250
Additional stabilization of submarine pipelines
Jinsi, B.K.; Chung, J.S.; Yoshida, K.; Sparks, C.P.; Tsahalis, D.T. (eds.)
JP Kenny Netherland, The Hague, Netherlands
5. International Offshore Mechanics and Arctic Engineering (OMAE) Symposium Tokyo (Japan) 13-18 Apr 1986
PROCEEDINGS OF THE FIFTH INTERNATIONAL OFFSHORE MECHANICS AND ARCTIC ENGINEERING (OMAE) SYMPOSIUM. VOLUME 3 pp. 717-724, 1986
AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, NY (USA)
SUMMARY LANGUAGE - ENGLISH

2/3/22
86-06246
Influence of structural boundary conditions on pipeline free span dynamics
Hobbs, R.E.; Chung, J.S.; Yoshida, K.; Sparks, C.P.; Tsahalis, D.T. (eds.)
Civ. Eng. Dep., Imperial Coll., London SW7 2AZ, UK
5. International Offshore Mechanics and Arctic Engineering (OMAE) Symposium Tokyo (Japan) 13-18 Apr 1986
PROCEEDINGS OF THE FIFTH INTERNATIONAL OFFSHORE MECHANICS AND ARCTIC ENGINEERING (OMAE) SYMPOSIUM. VOLUME 3 pp. 685-691, 1986
AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, NY (USA)
SUMMARY LANGUAGE - ENGLISH

2/3/23
86-06244
Two-dimensional scour below pipelines
Hansen, E.A.; Fredsoee, J.; Ye, M.; Chung, J.S.; Yoshida, K.; Sparks, C.P.; Tsahalis, D.T. (eds.)
Inst. Hydrodyn. and Hydraul. Eng., Tech. Univ. Denmark, Copenhagen,

Denmark
5. International Offshore Mechanics and Arctic Engineering (OMAE) Symposium Tokyo (Japan) 13-18 Apr 1986
PROCEEDINGS OF THE FIFTH INTERNATIONAL OFFSHORE MECHANICS AND ARCTIC ENGINEERING (OMAE) SYMPOSIUM. VOLUME 3 pp. 670-678, 1986
AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, NY (USA)
SUMMARY LANGUAGE - ENGLISH

2/3/24
86-06241
Nonlinear random response of marine pipelines in contact with the seabed
Michalopoulos, C.D.; Chung, J.S.; Yoshida, K.; Sparks, C.P.; Tsahalis, D.T. (eds.)
Southwest Applied Mechanics, Inc., Houston, TX, USA
5. International Offshore Mechanics and Arctic Engineering (OMAE) Symposium Tokyo (Japan) 13-18 Apr 1986
PROCEEDINGS OF THE FIFTH INTERNATIONAL OFFSHORE MECHANICS AND ARCTIC ENGINEERING (OMAE) SYMPOSIUM. VOLUME 3 pp. 639-646, 1986
AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, NY (USA)
SUMMARY LANGUAGE - ENGLISH

2/3/25
86-06226
A circular cylinder partly submerged in three turbulent boundary layers
Zdravkovich, M.M.; Chung, J.S.; Yoshida, K.; Sparks, C.P.; Tsahalis, D.T. (eds.)
Univ. Salford, Salford, Lancashire M5 4WT, UK
5. International Offshore Mechanics and Arctic Engineering (OMAE) Symposium Tokyo (Japan) 13-18 Apr 1986
PROCEEDINGS OF THE FIFTH INTERNATIONAL OFFSHORE MECHANICS AND ARCTIC ENGINEERING (OMAE) SYMPOSIUM. VOLUME 3 pp. 582-587, 1986
AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, NY (USA)
SUMMARY LANGUAGE - ENGLISH

2/3/26
86-06133
Hydrodynamic forces due to oblique wave and current action on marine pipelines
Bryndum, M.B.; Jacobsen, V.; Madsen, M.; Brand, L.P.; Chung, J.S.; Yoshida, K.; Sparks, C.P.; Tsahalis, D.T. (eds.)
Danish Hydraul. Inst., Horsholm, Denmark
5. International Offshore Mechanics and Arctic Engineering (OMAE) Symposium Tokyo (Japan) 13-18 Apr 1986
PROCEEDINGS OF THE FIFTH INTERNATIONAL OFFSHORE MECHANICS AND ARCTIC ENGINEERING (OMAE) SYMPOSIUM. VOLUME 3 pp. 402-407, 1986
AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, NY (USA)
SUMMARY LANGUAGE - ENGLISH

2/3/27
86-05593
Proceedings of the Fifth International Offshore Mechanics and Arctic Engineering (OMAE) Symposium. Volume 3
Chung, J.S.; Yoshida, K.; Sparks, C.P.; Tsahalis, D.T. (eds.)
5. International Offshore Mechanics and Arctic Engineering (OMAE) Symposium Tokyo (Japan) 13-18 Apr 1986
1986
AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, NY (USA)

2/3/28
86-04458
The Benigraph: A sea-floor mapping system
Loevik, A.
Bentech A/S, Tromsoe, Norway
International Conference, Offshore Site Investigation London, (UK) 13 Mar 1985
ADVANCES IN UNDERWATER TECHNOLOGY AND OFFSHORE ENGINEERING. VOLUME 3.

OFFSHORE SITE INVESTIGATION pp. 63-68. 1985
GRAHAM AND TROTMAN, LONDON (UK)
SUMMARY LANGUAGE - ENGLISH

2/3/29
86-04451
Oahu OTEC preliminary design: Sea-floor surveys
Niedoroda, A.W.; Palmer, A.C.; Pittman, J.R.; Vandermeulen, J.P.; Campbell, J.F.
Inst. Geophys., Univ. Hawaii, Honolulu, HI 96813, USA
International Conference, Offshore Site Investigation London, (UK) 13 Mar 1985
ADVANCES IN UNDERWATER TECHNOLOGY AND OFFSHORE ENGINEERING. VOLUME 3. OFFSHORE SITE INVESTIGATION pp. 15-28. 1985
GRAHAM AND TROTMAN, LONDON (UK)
SUMMARY LANGUAGE - ENGLISH

2/3/30
86-04298
Dynamic behavior of deep-ocean pipeline
Zimmerman, M.; Hudspeth, R.; Leonard, J.; Tedesco, J.; Borgman, L.
Standard Oil California, San Francisco, CA 94105, USA
J. WATERWAY PORT COAST. OCEAN ENG. AM. SOC. CIV. ENG VOL. 112, NO. 2, pp. 183-199. 1986
SUMMARY LANGUAGE - ENGLISH

2/3/31
85-07957
Pipeline breakout from sea floor under wave action
Foda, M.A.
Kuwait Inst. Sci. Res., PO Box 24885, Safat, Kuwait
APPL. OCEAN RES VC 7, NO. 2, pp. 79-84, 1985
SUMMARY LANGUAGE - ENGLISH
?b44

2/3/1
0339550 220-08705
Numerical modelling of erosion and sedimentation around offshore pipelines.
van Beek, F.A.;Wind, H.G.

Delft Hydraul., De Voorst Off., P.O. Box 152, 8300 AD Emmeloord, Netherlands
COAST. ENG., vol. 14, no. 2, pp. 107-128, (1990).

2/3/2
0339494 220-08639
Analysis of water surface oscillations induced by waves in the pits of the intake pipeline.; Oceans '89; Seattle, WA (USA); 18-21 Sep 1989
Ishino, K.
Technol. Res. Cent., Taisei Corp., 344-1 Nasemachi Totukaku, Yokohama 245, Japan
OCEANS '89
OCEANS '89: THE GLOBAL OCEAN. VOLUME 5: DIVING SAFETY AND PHYSIOLOGY. OCEAN ENGINEERING/TECHNOLOGY.
, 1989., pp. 1567-1570

2/3/3
0329681 220-06241
Hydrodynamic forces on seabed pipelines.; Ocean Technology Conf.; Houston, TX (USA); 27-30 Apr 1987
Verley, R.L.P.;Lambrakos, K.F.;Reed, K.
Statoil, Postuttak, 7004 Trondheim, Norway
J. WATERWAY PORT COAST. OCEAN ENG., vol. 115, no. 2, pp. 190-204, (1989).

2/3/4
0329669 220-06229
The effect of the sea-bottom proximity on the hydrodynamic forces for submarine pipelines.
E, Xuequan;Li, Zhanhua;Ling, Guocan
Inst. Mech., Acad. Sinica, Beijing, People's Rep. China
THE OCEAN ENG. HAIYANG GONGCHENG, vol. 7, no. 1, pp. 90-100, (1989).

2/3/5
0299587 219-06916
Combined wave and current boundary layer model for fixed rough seabeds.
Myrhaug, D.; Slaattelid, O.H.
Div. Mar. Hydrodyn., Norwegian Inst. Technol., N-7034 Trondheim-NTH, Norway
OCEAN ENG., vol. 16, no. 2, pp. 119-142, (1989).

2/3/6
0293814 219-05454
Seismic response of buried submarine pipelines.
Datta, T.K.; Mashaly, E.A.
Dep. Civ. Eng., Indian Inst. Technol., Delhi, Hauz-Khas, New Delhi, India
J. ENERGY RESOUR. TECHNOL., vol. 110, no. 4, pp. 208-219, (1988).

2/3/7
0288133 219-03781
Vortex-shedding response of long cylindrical structures in shear flow. 5. International Symposium and Exhibit on Offshore Mechanics and Arctic Engineering Tokyo (Japan) 13-22 Apr 1986
Wang, E.; Whitney, A.K.; Nikkel, K.G.
Lockheed Missiles and Space Co., Inc., Sunnyvale, CA 94086, USA
J. OFFSHORE MECH. ARCT. ENG., vol. 110, no. 1, pp. 24-31, (1988).

2/3/8
0286778 119-11058; 219-03902
Wastewater management for coastal cities: The ocean disposal option.
Gunnerson, C.G.
International Bank for Reconstruction and Development, Washington, DC (USA)
TECH. PAP. WORLD BANK., no. 77
, 1988., 422 pp

2/3/9

0285263 219-02968
Cameron introduces space age titanium to the subsea.
Anon.
SEA TECHNOL., vol. 29, no. 6, pp. 39-40, (1988).

2/3/10
0285262 219-02967
Thermal buckling of offshore pipelines.
Ju, G.T.; Kyriakides, S.
Eng. Mech. Res. Lab., Dep. Aerosp. Eng. and Eng. Mech., Univ. Texas, Austin, TX 78712, USA
J. OFFSHORE MECH. ARCT. ENG., vol. 110, no. 4, pp. 355-364, (1988).

2/3/11
0282397 219-02221
Haidi guanxian puguan zuoye zhuangtai fenxi
On the analysis of pipeline during laying operation.
Gu, Yongning
Shanghai Jiaotong Univ., Shanghai, People's Rep. China
THE OCEAN ENG. HAIYANG GONGCHENG., vol. 6, no. 2, pp. 11-23, (1988).

2/3/12
0282396 219-02220
Haiyang youqi guandao jixian chongshua changdu de tantao
Discussion on the limit erosion length of the ocean oil and gas pipeline.
Yuan, Xiangzhong; Zheng, Liang
Southwestern Pet. Inst., People's Rep. China
THE OCEAN ENG. HAIYANG GONGCHENG., vol. 6, no. 2, pp. 1-10, (1988).

2/3/13
0279469 219-01414
Acoustics in control for Balmoral pipelines.
Anon.
OFFSHORE ENG., p. 55, (1986).

2/3/14
0279451 219-01395
Stress analysis of marine pipelines crossing elevated obstructions or lowered depressions at seabed.
Zhu, Fugen
Dep. Nav. Architect. and Ocean Eng., Shanghai Jiaotong Univ., Shanghai, People's Rep. China
CHINA OCEAN ENG., vol. 1, no. 4, pp. 109-116, (1987).

2/3/15
0276500 219-00565
PIPESTAB project: Improved design basis for submarine pipeline stability.
19. Annual Offshore Technology Conference Houston, TX (USA) 27-30 Apr 1987
Wolfram, W.E., Jr.; Getz, J.R.; Verley, R.L.P.
Exxon Production Research Co., USA
PROC. OFFSHORE TECHNOL. CONF.
NINETEENTH ANNUAL OFFSHORE TECHNOLOGY CONFERENCE. 1987 PROCEEDINGS.
. 1987., pp. 153-158

2/3/16
0266072 218-06190
Wave induced forces on submarine pipelines. Int. Conf. on Measuring Techniques of Hydraulics Phenomena in Offshore, Coastal and Inland Waters London (UK) 9-11 Apr 1986
Shankar, N.J.; Fatt, C.H.; Subbiah, K.
Dep. Civ. Eng., Natl. Univ. Singapore, Kent Ridge, Singapore 0511, Singapore
INTERNATIONAL CONFERENCE ON MEASURING TECHNIQUES OF HYDRAULICS PHENOMENA IN OFFSHORE, COASTAL AND INLAND WATERS LONDON, ENGLAND: 9-11 APRIL, 1986.
Pounsford, J.H.
ed.

, 1986., pp. 137-148

2/3/17
0266070 218-06188
Wave-induced forces on buried pipelines.
McDougal, W.G.; Davidson, S.H.; Monkmeyer, P.L.; Sollitt, C.K.
Ocean Eng. Program, Dep. Civ. Eng., Oregon State Univ., Corvallis, OR 97331. USA
J. WATERWAY PORT COAST. OCEAN ENG., vol. 114, no. 2, pp. 220-236, (1988).

2/3/18
0263434 218-04522
Simplex provides flexible pipe Offshore Petroleum Delivery System (OPDS) to the U.S. Navy. Oceans '85 "Engineering and the Environment" San Diego, CA (USA) 12-14 Nov 1985
Dubois, B.C.
Simplex Wire and Cable Co., USA
OCEANS '85.
OCEANS '85 PROCEEDINGS: OCEAN ENGINEERING AND THE ENVIRONMENT.
, 1985., vol. 2, pp. 1244-1252

2/3/19
0259865 218-03869
Offshore oil and gas technology assessment. Oceans '85 "Engineering and the Environment" San Diego, CA (USA) 12-14 Nov 1985
Otteman, L.G.; Crooke, R.C.; Shoemaker, R.
Shell California Product., Inc., CA, USA
OCEANS '85.
OCEANS '85 PROCEEDINGS: OCEAN ENGINEERING AND THE ENVIRONMENT.
, 1985., vol. 1, pp. 4-16

2/3/20
0259569 218-03558
Ice gouge hazard analysis. 18. Annual Offshore Technology Conference Houston, TX (USA) 5-8 May 1986
Lanan, G.A.; Niedoroda, A.W.; Weeks, W.F.
PROC. OFFSHORE TECHNOL. CONF.
EIGHTEENTH ANNUAL OFFSHORE TECHNOLOGY CONFERENCE. 1986 PROCEEDINGS.
, 1986., pp. 57-66

2/3/21
0247852 217-07730
Nonlinear dynamic response of submarine pipelines in contact with the ocean floor.
Chung, C.K.
University of Houston, Texas (USA)
DISS. ABST. INT. PT. B - SCI. & ENG., vol. 48, no. 1
, 1987., 266 pp

2/3/22
0239454 217-04507
A concept for design of submarine pipelines to resist ocean forces. 3. International Symposium on Offshore Mechanics and Arctic Engineering New Orleans, LA (USA) 12-16 Feb 1984
Karal, K.
SINTEF, Trondheim, Norway
J. ENERGY RESOUR. TECHNOL., vol. 107, no. 1, pp. 42-47, (1985).

2/3/23
0237542 217-03785
Optimum design of submarine suspended pipelines.
Huang, Z.; Seireg, A.
Res. Inst. Pet., Explor. and Dev., Beijing, People's Rep. China
J. ENERGY RESOUR. TECHNOL., vol. 107, no. 3, pp. 335-341, (1985).

2/3/24

0231622 217-01321
Operational experience with the cold water pipe at the Natural Energy Laboratory of Hawaii. Oceans '86 "Science-Engineering-Adventure" Washington, DC (USA) 22-25 Sep 1986
Daniel, T.H.
Natural Energy Lab. of Hawaii, P.O. Box 1749, Kailua-Kona, HI 96745, USA
OCEANS '86.
OCEANS '86 CONFERENCE RECORD: SCIENCE-ENGINEERING-ADVENTURE. VOL. 1. SYSTEMS, STRUCTURES AND ANALYSIS.
, 1986., pp. 185-190

2/3/25
0231583 217-01280
Wave induced forces on submarine pipelines. International Conference on Measuring Techniques of Hydraulics Phenomena in Offshore, Coastal and Inland Waters London (UK) 9-11 Apr 1986
Shankar, N.J.; Subbiah, K.
Dep. Civ. Eng., Natl. Univ. Singapore, Kent Ridge 0511, Singapore
PAPERS PRESENTED AT THE INTERNATIONAL CONFERENCE ON MEASURING TECHNIQUES OF HYDRAULICS PHENOMENA IN OFFSHORE, COASTAL AND INLAND WATERS. LONDON, ENGLAND: 9-11 APRIL, 1986.
, 1986., pp. 137-148

2/3/26
0219484 216-06354
Additional stabilization of submarine pipelines. 5. International Offshore Mechanics and Arctic Engineering (OMAE) Symposium Tokyo (Japan) 13-18 Apr 1986
Jinsi, B.K.
JP Kenny Netherland, The Hague, Netherlands
PROCEEDINGS OF THE FIFTH INTERNATIONAL OFFSHORE MECHANICS AND ARCTIC ENGINEERING (OMAE) SYMPOSIUM. VOLUME 3.
Chung, J.S.; Yoshida, K.; Sparks, C.P.; Tsahalis, D.T.
eds.
, 1986., pp. 717-724

2/3/27
0219438 216-06302
Two-dimensional scour below pipelines. 5. International Offshore Mechanics and Arctic Engineering (OMAE) Symposium Tokyo (Japan) 13-18 Apr 1986
Hansen, E.A.; Fredsoee, J.; Ye, M.
Inst. Hydrodyn. and Hydraul. Eng., Tech. Univ. Denmark, Copenhagen, Denmark
PROCEEDINGS OF THE FIFTH INTERNATIONAL OFFSHORE MECHANICS AND ARCTIC ENGINEERING (OMAE) SYMPOSIUM. VOLUME 3.
Chung, J.S.; Yoshida, K.; Sparks, C.P.; Tsahalis, D.T.
eds.
, 1986., pp. 670-678

2/3/28
0219436 216-06300
Nonlinear random response of marine pipelines in contact with the seabed. 5. International Offshore Mechanics and Arctic Engineering (OMAE) Symposium Tokyo (Japan) 13-18 Apr 1986
Michalopoulos, C.D.
Southwest Applied Mechanics, Inc., Houston, TX, USA
PROCEEDINGS OF THE FIFTH INTERNATIONAL OFFSHORE MECHANICS AND ARCTIC ENGINEERING (OMAE) SYMPOSIUM. VOLUME 3.
Chung, J.S.; Yoshida, K.; Sparks, C.P.; Tsahalis, D.T.
eds.
, 1986., pp. 639-646

2/3/29
0219429 216-06293
A circular cylinder partly submerged in three turbulent boundary layers.

Tokyo (Japan) 13-18 Apr 1986
Zdravkovich, M.M.
Univ. Salford, Salford, Lancashire M5 4WT, UK
PROCEEDINGS OF THE FIFTH INTERNATIONAL OFFSHORE MECHANICS AND ARCTIC ENGINEERING (OMAE) SYMPOSIUM. VOLUME 3.
Chung, J.S.; Yoshida, K.; Sparks, C.P.; Tsahalis, D.T.
eds.
, 1986., pp. 582-587

2/3/30
0219405 216-06269
Hydrodynamic forces due to oblique wave and current action on marine pipelines. 5. International Offshore Mechanics and Arctic Engineering (OMAE) Symposium Tokyo (Japan) 13-18 Apr 1986
Bryndum, M.B.; Jacobsen, V.; Madsen, M.; Brand, L.P.
Danish Hydraul. Inst., Horsholm, Denmark
PROCEEDINGS OF THE FIFTH INTERNATIONAL OFFSHORE MECHANICS AND ARCTIC ENGINEERING (OMAE) SYMPOSIUM. VOLUME 3.
Chung, J.S.; Yoshida, K.; Sparks, C.P.; Tsahalis, D.T.
eds.
, 1986., pp. 402-407

2/3/31
0219384 216-06246
Influence of structural boundary conditions on pipeline free span dynamics. 5. International Offshore Mechanics and Arctic Engineering (OMAE) Symposium Tokyo (Japan) 13-18 Apr 1986
Hobbs, R.E.
Civ. Eng. Dep., Imperial Coll., London SW7 2AZ, UK
PROCEEDINGS OF THE FIFTH INTERNATIONAL OFFSHORE MECHANICS AND ARCTIC ENGINEERING (OMAE) SYMPOSIUM. VOLUME 3.
Chung, J.S.; Yoshida, K.; Sparks, C.P.; Tsahalis, D.T.
eds.
, 1986., pp. 685-691

2/3/32
0217475 216-05536
Proceedings of the Fifth International Offshore Mechanics and Arctic Engineering (OMAE) Symposium. Volume 3. 5. International Offshore Mechanics and Arctic Engineering (OMAE) Symposium Tokyo (Japan) 13-18 Apr 1986
Chung, J.S.; Yoshida, K.; Sparks, C.P.; Tsahalis, D.T.
eds.
PUBL: AMERICAN SOCIETY OF MECHANICAL ENGINEERS, NEW YORK, NY (USA), 1986.
, 736 pp

2/3/33
0213759 215-06673
Pipeline breakout from sea floor under wave action.
Foda, M.A.
Kuwait Inst. Sci. Res., PO Box 24885, Safat, Kuwait
APPL. OCEAN RES., vol. 7, no. 2, pp. 79-84. (1985).

2/3/34
0213707 216-04118
Dynamic behavior of deep-ocean pipeline.
Zimmerman, M.; Hudspeth, R.; Leonard, J.; Tedesco, J.; Borgman, L.
Standard Oil California, San Francisco, CA 94105, USA
J. WATERWAY PORT COAST. OCEAN ENG. AM. SOC. CIV. ENG., vol. 112, no. 2, pp. 183-199, (1986).

2/3/35
0211610 216-03088
Oahu OTEC preliminary design: Sea-floor surveys. International Conference, Offshore Site Investigation London, (UK) 13 Mar 1985

Niedoroda, A.W.; Palmer, A.C.; Pittman, J.R.; Vandermeulen, J.P.; Campbell, J.F.
Inst. Geophys., Univ. Hawaii, Honolulu, HI 96813, USA

ADVANCES IN UNDERWATER TECHNOLOGY AND OFFSHORE ENGINEERING. VOLUME 3. OFFSHORE SITE INVESTIGATION.
, 1985., pp. 15-28

2/3/36
0211604 216-03080
The Benigraph: A sea-floor mapping system. International Conference, Offshore Site Investigation London, (UK) 13 Mar 1985
Loevik, A.
Bentech A/S, Tromsoe, Norway
ADVANCES IN UNDERWATER TECHNOLOGY AND OFFSHORE ENGINEERING. VOLUME 3. OFFSHORE SITE INVESTIGATION.
PUBL: GRAHAM AND TROTMAN, LONDON (UK), 1985., pp. 63-68

2/3/37
0186049 215-03706
Dutch rock dumper eyes deepwater prospects.
Anon.
OFFSHORE ENG., pp. 47-48, (1985).
?bogoff

2/5/1
03033439 E.I. Monthly No: EI9103031805
Title: Wave-induced breakout of half-buried marine pipes.
Author: Foda, Mostafa; Chang, Y. -H.; Law, Adrian W. -K.
Corporate Source: Univ. of California, Berkeley, CA, USA
Source: Journal of Waterway, Port, Coastal and Ocean Engineering v 116 n
2 Mar-Apr 1990 p 267-286.

. . . Resources . . .

Long term issue, looking at state water policy

A presentation by the Water Resources Board sparked a lengthy discussion of the state's water policy in a House Resources Committee meeting last week.

Resources Chair Rep. Cliff Davidson asked the Board and state and federal officials for ideas on establishing a sound water policy for the state of Alaska. One commonly-expressed idea was the need for adequate data on the state's water resources, in an easily-retrieved and usable format. Mary Lu Harle of the Dept. of Natural Resources compared the lack of data to a checking account. "It's hard to write out checks for water if you don't know how much is there," she said.

An analysis of the state's present and projected future needs of our water resources is needed. Gary Gustafson of DNR suggested the need for a policy to establish preferences among water uses, and cooperative planning among various water users.

State water program ?

Bill Long, Chief of the Water Resources Section of DNR cited two main areas of emphasis for his office this year: (1) water resources of the state's land entitlement selections; and (2) groundwater quality and supply for Alaska's communities. Rep. Bill Hudson and Rep. Georgianna Lincoln expressed dismay that the Governor is talking about exporting water to California, while he cannot ensure safe drinking water in many of Alaska's communities. Long admitted that the state is falling behind in collecting water resources data. Rep. Davidson said that he would like to see DNR ask for more money for this effort.

Gathering water data

Phil Carpenter of the USGS recommended a "network evaluation" of the state's water resources. That, he said, would tell us how accurate our data is. It would also tell us where to focus future data collection efforts. The cost of a study would be approximately $400,000, half of which could be paid for with federal funds.

Just because Alaska is a "water-rich" state, Carpenter said, doesn't mean that we don't need a sound water policy. He cited the state of Washington, also a water-rich state, is now facing a dilemma over water rights. The Board presented 12 resolutions to the committee, several dealing with data for water resources.

Concern was expressed by both the board and the committee members that the Dept. of Natural Resources is now using *one-quarter* the amount of federal funds that it was using eight years ago for data collection. One particular area where data collection is needed is in the Arctic National Wildlife Refuge. The Board recommended that DNR take full advantage of all federal matching funds available for data collection.

Board chair Peg Tileston recommended a network of stream gauging, as well as funding for the STORET program, which she called an efficient data storage and retrieval system.

The Board also called for an interagency task force charged with studying the impacts on village water and waste systems of agency projects. Currently, there is no coordinated approach for state agency projects in villages, which can end up placing too-heavy demands on existing systems. The board suggests keeping "as-builts" on the site of utility systems, so that rural maintenance personnel have some reference materials on the systems they are expected to maintain.

Wetlands policy

An aggressive campaign to influence national wetlands policy with regard to its treatment or regulation of Alaska lands is urged by the Board as well.

In response to Gov. Hickel's proposal to export water to California, the Board is recommending a study, *not funded by the state of Alaska,* to analyze the impacts of such a project on Alaska's people, fisheries, and land and water resources.

The Board also called for a $25 million appropriation to the Oil and Hazardous Substance Release Response Fund (the "470 fund"), and that this fund be kept in reserve for use on major oil and other hazardous substance spills. Regarding a hazardous waste disposal site in the state, the board recommended a cost-analysis be done by the Dept. of Environmental Conservation, and that if such a site is created in Alaska, that adequate groundwater protection is assured.

ANWR Resolution

The House Resources last week passed out HJR-21, endorsing ANWR exploration and development and objecting to any decrease in the state revenue share. The resolution was amended to include language re: protection of habitat for the Porcupine caribou herd, as well as other land, water and wildlife resources. HJR-21 now goes to the House Finance.

Water Resources Data
Alaska
Water Year 1989

U.S. GEOLOGICAL SURVEY WATER-DATA REPORT AK-89-1
Prepared in cooperation with the State of Alaska
and with other agencies

DISCHARGE AT MISCELLANEOUS SITES

Discharge measurements made at miscellaneous sites during water year 1989

Stream	Tributary to	Location	Drainage area (mi^2)	Measured previously (water years)	Measurements Date	Measurements Discharge (ft^3/s)
		Southeast Alaska				
15044000 Dorothy Creek near Juneau	Taku Inlet	Lat 58°13'40", long 134°02'25", City and Borough of Juneau, 0.7 mi downstream from Lake Barr, 0.8 mi upstream from mouth, 3 mi downstream from Lake Dorothy, and 14 mi southeast of Juneau.	15.2	‡1929-67	12- 5-88	160
Jordan Creek at west end of Jordan Creek Mall near Auke Bay	Gastineau Channel	Lat 58°21'53", long 134°34'40", in NE¼ NW¼ sec.31, T.40 S., R.66 E., City and Borough of Juneau, 0.8 mi upstream from mouth, and 8 mi northwest of Juneau.	--	1988	3- 2-89	no flow
Duck Creek at Mendenhall Blvd. near Auke Bay	Mendenhall River	Lat 58°23'34", long 134°34'06", in NE¼ NE¼ sec.19, T.40 S., R.66 E., City and Borough of Juneau, 2.8 mi upstream from mouth, and 8 mi northwest of Juneau.	--	1988	3- 2-89	e0.75
Duck Creek at Steven Richards Blvd. near Auke Bay	Mendenhall River	Lat 58°23'03", long 134°34'31", in NW¼ SE¼ sec.19, T.40 S., R.66 E., City and Borough of Juneau, 2.1 mi upstream from mouth, and 8 mi northwest of Juneau.	--	1988	3- 2-89	0.28
Duck Creek at Delrae Rd. near Auke Bay	Mendenhall River	Lat 58°22'04", long 134°35'16", in SW¼ SW¼ sec.30, T.40 S., R.66 E., City and Borough of Juneau, 0.8 mi upstream from mouth, and 8 mi northwest of Juneau.	--	1988	3- 2-89	no flow
Mendenhall River near Auke Bay	Gastineau Channel	Lat 58°23'22", long 134°35'30", in SE¼ NE¼ sec.24, T.40 S., R.65 E., City and Borough of Juneau, 3.5 mi upstream from mouth, and 2.0 mi east of Auke Bay.	--	1984	3- 2-89	32
Mendenhall River near Auke Bay	Gastineau Channel	Lat 58°22'52", long 134°35'34", in SE¼ SE¼ sec.24, T.40 S., R.65 E., City and Borough of Juneau, 2.7 mi upstream from mouth, and 2.0 mi southeast of Auke Bay.	--	1984	3- 2-89	39
Montana Creek near Auke Bay	Mendenhall River	Lat 58°22'56", long 134°35'50", in SE¼ SE¼ sec.24, T.40 S., R.65 E., City and Borough of Juneau, 0.05 mi upstream from mouth, and 1.8 mi east of Auke Bay.	--	1965-68, 1984	3- 2-89	11
15052900 Mendenhall River at Brotherhood Bridge near Juneau	Gastineau Channel	Lat 58°22'15", long 134°36'00", in NW¼ SE¼ sec.25, T.40 S., R.65 E., City and Borough of Juneau, at Brotherhood Bridge, 1.6 mi upstream from mouth, and 2.2 mi southeast of Auke Bay.	--	1950, 1969, 1984	4- 2-50 11-20-68 11-20-68 3- 2-89	2820 g150 g111 59
East Mine Drainage Creek below Pond	Greens Creek	Lat 58°04'38", long 134°37'39", on Admiralty Island, at settling pond outlet, and 19 mi southwest of Juneau.	--	1983-84, 1988	8-31-89	0.04
*Greens Creek below West Mine Drainage Creek	Hawk Inlet	Lat 58°04'44", long 134°38'37", on Admiralty Island, about 200 ft upstream from Gallagher Creek, 6.1 mi upstream from mouth, and 19 mi southwest of Juneau.	--	1978-80, 1983, 1988	8-29-89	11
Zinc Creek near Juneau	Greens Creek	Lat 58°05'39", long 134°44'24", on Admiralty Island, about 0.5 mi upstream from mouth, and 19 mi southwest of Juneau.	--	1978	8-18-78 8-31-89	eg12 1.8
*Tributary to Zinc Creek near Juneau	Zinc Creek	Lat 58°05'47", long 134°44'27", on Admiralty Island, 19 mi southwest of Juneau.	--	--	8-31-89	0.12

‡ Operated as a continuous-record station.
* See analyses of samples collected at miscellaneous water-quality sites.
e Estimated.
g Not previously published.

ANALYSES OF SAMPLES COLLECTED AT MISCELLANEOUS SITES

SOUTHEAST ALASKA

580444134383700 GREENS CREEK BELOW WEST MINE DRAINAGE CREEK NEAR JUNEAU

WATER QUALITY DATA, WATER YEAR OCTOBER 1988 TO SEPTEMBER 1989

DATE	TIME	DIS-CHARGE, INST. CUBIC FEET PER SECOND (00061)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	PH (STAND-ARD UNITS) (00400)	TEMPER-ATURE WATER (DEG C) (00010)	TUR-BID-ITY (NTU) (00076)	BARO-METRIC PRES-SURE (MM OF HG) (00025)	OXYGEN, DIS-SOLVED (MG/L) (00300)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION) (00301)	HARD-NESS TOTAL (MG/L AS CACO3) (00900)	HARD-NESS NONCARB WH WAT TOT FLD MG/L AS CACO3 (00902)
AUG 29...	1430	11	138	7.80	10.5	0.30	743	9.5	87	71	24

DATE	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	ALKA-LINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	ALKA-LINITY WAT WH TOT IT FIELD MG/L AS CACO3 (00419)	BICAR-BONATE WATER DIS IT FIELD MG/L AS HCO3 (00453)	CAR-BONATE WATER DIS IT FIELD MG/L AS CO3 (00452)	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)	FLUO-RIDE, DIS-SOLVED (MG/L AS F) (00950)
AUG 29...	22	3.9	1.8	0.20	47	47	58	0	20	1.2	0.20

DATE	SILICA, DIS-SOLVED (MG/L AS SIO2) (00955)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N) (00608)	NITRO-GEN, ORGANIC DIS-SOLVED (MG/L AS N) (00607)	NITRO-GEN, AM-MONIA + ORGANIC DIS. (MG/L AS N) (00623)	PHOS-PHORUS DIS-SOLVED (MG/L AS P) (00666)	PHOS-PHOROUS ORTHO, DIS-SOLVED (MG/L AS P) (00671)	ALUM-INUM, TOTAL RECOV-ERABLE (UG/L AS AL) (01105)
AUG 29...	4.5	85	83	0.150	0.040	0.26	0.30	<0.010	0.020	20

DATE	ALUM-INUM, DIS-SOLVED (UG/L AS AL) (01106)	ARSENIC TOTAL (UG/L AS AS) (01002)	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	BARIUM, TOTAL RECOV-ERABLE (UG/L AS BA) (01007)	BARIUM, DIS-SOLVED (UG/L AS BA) (01005)	CADMIUM TOTAL RECOV-ERABLE (UG/L AS CD) (01027)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CHRO-MIUM, TOTAL RECOV-ERABLE (UG/L AS CR) (01034)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)	COBALT, TOTAL RECOV-ERABLE (UG/L AS CO) (01037)
AUG 29...	10	<1	<1	200	38	<1	<1	<1	1	<1

DATE	COBALT, DIS-SOLVED (UG/L AS CO) (01035)	COPPER, TOTAL RECOV-ERABLE (UG/L AS CU) (01042)	COPPER, DIS-SOLVED (UG/L AS CU) (01040)	IRON, TOTAL RECOV-ERABLE (UG/L AS FE) (01045)	IRON, DIS-SOLVED (UG/L AS FE) (01046)	LEAD, TOTAL RECOV-ERABLE (UG/L AS PB) (01051)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	MANGA-NESE, TOTAL RECOV-ERABLE (UG/L AS MN) (01055)	MANGA-NESE, DIS-SOLVED (UG/L AS MN) (01056)	MERCURY TOTAL RECOV-ERABLE (UG/L AS HG) (71900)
AUG 29...	<1	4	<1	80	11	2	<1	<10	8	0.10

DATE	MERCURY DIS-SOLVED (UG/L AS HG) (71890)	NICKEL, TOTAL RECOV-ERABLE (UG/L AS NI) (01067)	NICKEL, DIS-SOLVED (UG/L AS NI) (01065)	SELE-NIUM, TOTAL (UG/L AS SE) (01147)	SELE-NIUM, DIS-SOLVED (UG/L AS SE) (01145)	SILVER, TOTAL RECOV-ERABLE (UG/L AS AG) (01077)	SILVER, DIS-SOLVED (UG/L AS AG) (01075)	ZINC, TOTAL RECOV-ERABLE (UG/L AS ZN) (01092)	ZINC, DIS-SOLVED (UG/L AS ZN) (01090)	OIL AND GREASE, TOTAL RECOV. GRAVI-METRIC (MG/L) (00556)
AUG 29...	0.1	1	1	1	1	<1	<1.0	10	6	<1

GROUND-WATER LEVEL DATA

SOUTHEAST ALASKA

JUNEAU

582359134352103. Local number, CD04006618CBCA3019.
LOCATION.--Lat 58°23'59", long 134°35'21", Hydrologic Unit 19060000, Mendenhall Loop Road, near Juneau. Owner: Harlan Olson.
AQUIFER.--Sand and gravel of the Quaternary System.
WELL CHARACTERISTICS.--Diameter 6 in, depth 40 ft, screened 30 to 40 ft.
INSTRUMENTATION.--Continuous strip-chart recorder November 1983 to August 1984. Digital recorder from August 1984 to current year.
DATUM.--Elevation of land-surface datum is 50.53 ft above National Geodectic Vertical Datum of 1929 (determined from levels survey). Measuring Point: Top of casing 1.00 ft above land-surface datum.
PERIOD OF RECORD.--November 1983 to current year.
EXTREMES FOR PERIOD OF RECORD.--Highest water level, 4.92 ft below land-surface datum, Oct. 2-3, 1987; lowest, 11.65 ft below land-surface datum, Mar. 22, 23, 1989.

DEPTH BELOW LAND SURFACE (WATER LEVEL) (FEET), WATER YEAR OCTOBER 1988 TO SEPTEMBER 1989
MINIMUM VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
5	6.76	6.58	6.46	9.45	9.48	10.99	10.83	9.05	7.33	9.42	8.53	8.79
10	5.57	6.93	6.43	9.72	9.91	11.28	10.32	7.86	7.93	9.54	8.72	8.94
15	5.79	7.09	6.76	9.66	10.23	11.44	8.97	7.62	8.28	9.40	8.92	9.33
20	5.60	7.03	7.15	9.95	10.47	11.56	8.68	7.67	8.66	9.45	8.98	9.32
25	5.89	7.34	8.24	9.99	10.79	11.56	8.77	8.22	8.90	9.19	9.22	7.01
EOM	6.34	6.44	8.99	9.12	10.92	11.41	8.93	7.81	9.07	9.41	9.47	6.71

WTR YR 1989 HIGH 5.57 OCT 9-10 LOW 11.65 MAR 22-23

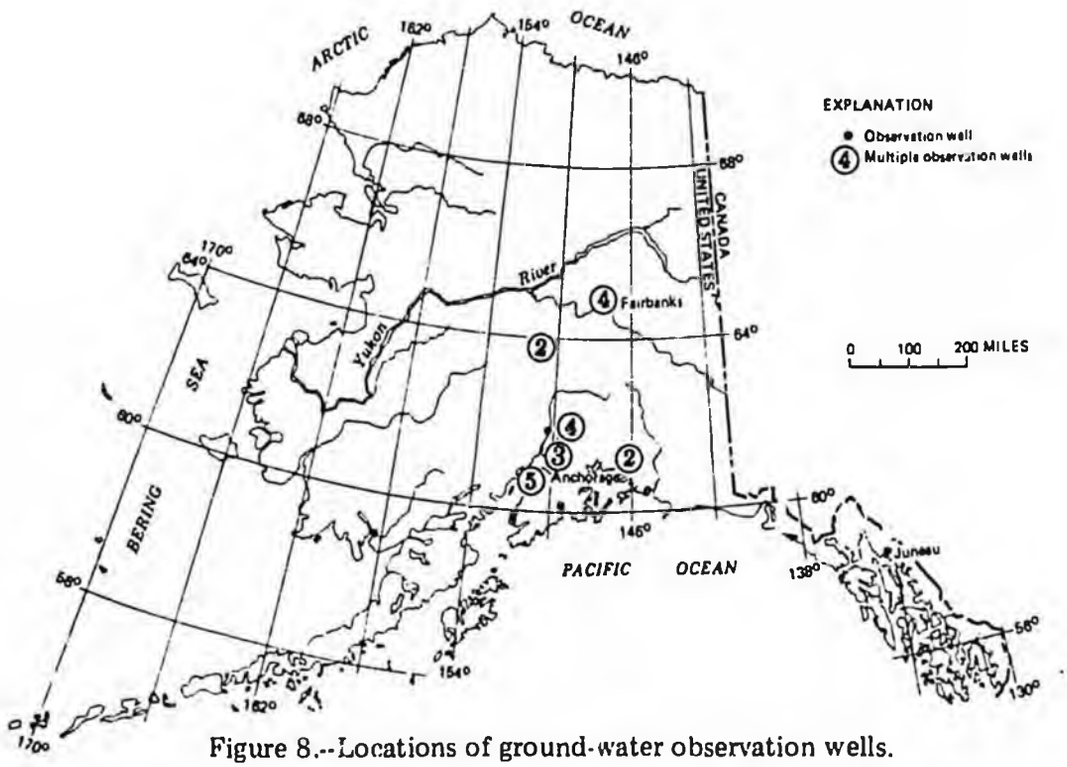


Figure 8.--Locations of ground-water observation wells.

QUALITY OF GROUND WATER

WATER QUALITY DATA COLLECTED FROM WELLS DURING WATER YEAR 1989

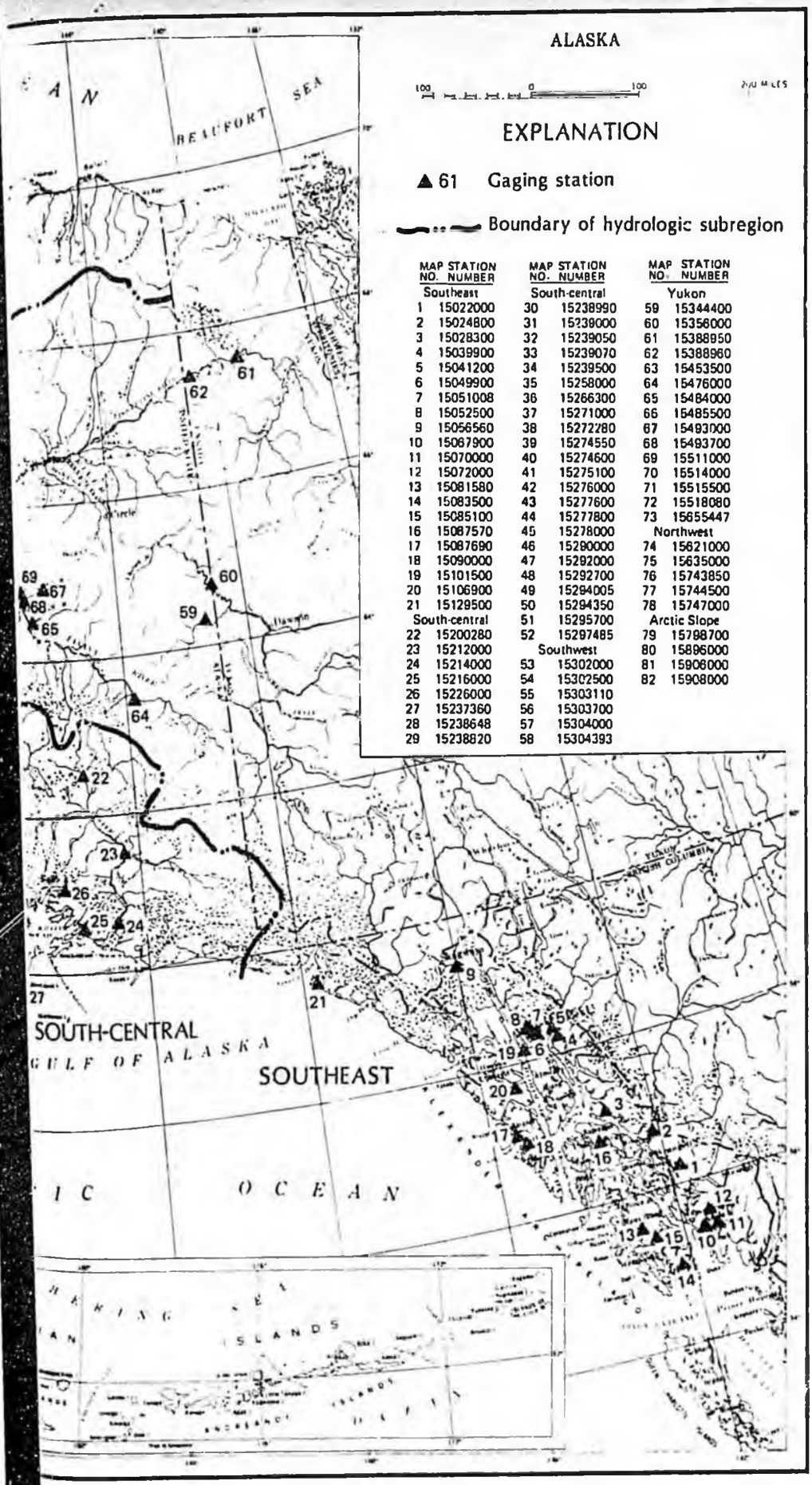
SOUTHEAST ALASKA

HAWK INLET WELLS

STATION NUMBER	LOCAL IDENTIFIER	DATE	TIME	DEPTH BELOW LAND SURFACE (WATER LEVEL) (FEET) (72019)	SPECIFIC CONDUCTANCE (US/CM) (00095)	PH (STANDARD UNITS) (00400)	TEMPERATURE WATER (DEG C) (00010)	HARDNESS TOTAL (MG/L AS CACO3) (00900)
580633134443301	CD04306526CDBB1 001	08-31-89	0857	0.9	234	6.50	10.0	75
580633134443302	CD04306526CDBB2 001	08-31-89	0735	43.9	909	9.00	7.5	20
580633134444001	CD04306526CBDD1 002	08-30-89	1435	0.2	154	6.00	10.5	45
580633134444002	CD04306526CBDD2 002	08-30-89	1410	0	204	8.60	7.5	70
580645134445201	CD04306526CBBB1 005	08-30-89	1207	2.4	137	5.40	10.5	19
580652134445401	CD04306526BCBD1 003	08-30-89	0930	1.2	196	4.70	10.0	59
580652134445402	CD04306526BCBD2 003	08-30-89	1120	28.8	516	8.70	9.0	23
580658134443201	CD04306526BDBB1 004	08-30-89	0800	0.8	169	7.60	10.0	82

STATION NUMBER	DATE	HARDNESS NONCARB WH WAT TOT FLD MG/L AS CACO3 (00902)	CALCIUM DISSOLVED (MG/L AS CA) (00915)	MAGNESIUM, DISSOLVED (MG/L AS MG) (00925)	SODIUM, DISSOLVED (MG/L AS NA) (00930)	POTASSIUM, DISSOLVED (MG/L AS K) (00935)	ALKALINITY WAT WH TOT FET FIELD MG/L AS CACO3 (00410)	ALKALINITY WAT WH TOT IT FIELD MG/L AS CACO3 (00419)	BICARBONATE WATER DIS IT FIELD MG/L AS HCO3 (00453)	CARBONATE WATER DIS IT FIELD MG/L AS CO3 (00452)
580633134443301	08-31-89	1	25	3.1	21	1.4	74	74	90	0
580633134443302	08-31-89	0	4.2	2.2	200	6.9	--	--	--	--
580633134444001	08-30-89	0	14	2.5	21	1.2	81	84	103	0
580633134444002	08-30-89	0	17	6.7	16	4.3	90	90	110	0
580645134445201	08-30-89	0	5.1	1.6	17	1.3	50	49	60	0
580652134445401	08-30-89	0	12	7.1	13	1.5	93	92	112	0
580652134445402	08-30-89	0	4.3	2.9	110	4.9	264	265	314	5
580658134443201	08-30-89	3	26	4.2	4.6	1.5	79	79	97	0

STATION NUMBER	DATE	SULFATE DISSOLVED (MG/L AS SO4) (00945)	CHLORIDE, DISSOLVED (MG/L AS CL) (00940)	FLUORIDE, DISSOLVED (MG/L AS F) (00950)	SILICA, DISSOLVED (MG/L AS SIO2) (00955)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L) (70301)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N) (00631)	NITROGEN, AMMONIA DISSOLVED (MG/L AS N) (00608)	NITROGEN, ORGANIC DISSOLVED (MG/L AS N) (00607)
580633134443301	08-31-89	<1.0	10	0.10	9.8	139	--	<0.100	0.120	0.68
580633134443302	08-31-89	25	69	1.0	15	--	540	0.300	0.130	0.77
580633134444001	08-30-89	<1.0	3.0	0.10	16	107	--	<0.100	0.070	0.73
580633134444002	08-30-89	10	4.4	0.10	16	115	129	<0.100	0.170	0.13
580645134445201	08-30-89	<1.0	4.3	0.20	15	115	--	<0.100	2.50	0.30
580652134445401	08-30-89	<1.0	3.1	0.10	17	128	--	<0.100	1.90	0.50
580652134445402	08-30-89	2.0	10	0.60	11	331	306	<0.100	0.050	0.35
580658134443201	08-30-89	4.0	3.6	0.20	16	115	108	<0.100	0.050	0.15



MAP NO.	STATION NUMBER
Southeast	
1	15022000
2	15024800
3	15028300
4	15039900
5	15041200
6	15049900
7	15051008
8	15052500
9	15056560
10	15067900
11	15070000
12	15072000
13	15081580
14	15083500
15	15085100
16	15087570
17	15087690
18	15090000
19	15101500
20	15106900
21	15129500
South-central	
22	15200280
23	15212000
24	15214000
25	15216000
26	15226000
27	15237360
28	15238648
29	15238820
South-central	
30	15238990
31	15239000
32	15239050
33	15239070
34	15239500
35	15258000
36	15266300
37	15271000
38	15272280
39	15274550
40	15274600
41	15275100
42	15276000
43	15277600
44	15277800
45	15278000
46	15280000
47	15292000
48	15292700
49	15294005
50	15294350
51	15295700
52	15297485
Southwest	
53	15302000
54	15302500
55	15303110
56	15303700
57	15304000
58	15304393
Yukon	
59	15344400
60	15356000
61	15388950
62	15388960
63	15453500
64	15476000
65	15484000
66	15485500
67	15493000
68	15493700
69	15511000
70	15514000
71	15515500
72	15518080
73	15655447
Northwest	
74	15821000
75	15835000
76	15743850
77	15744500
78	15747000
Arctic Slope	
79	15798700
80	15896000
81	15906000
82	15908000

Iron is present in objectionable concentrations in a large portion of shallow wells in most areas of the state. Concentrations in excess of 1.0 mg/L are common. Iron concentrations of more than about 0.3 mg/L can cause staining of laundry and plumbing fixtures and impart an unpleasant taste to the water.

One of the few areas of Alaska where natural ground-water quality could be considered generally poor is in the Copper River basin. As a general rule the quality of ground water decreases with increasing depth throughout the Copper River lowland. Saline springs which occur in the area are the surface manifestation of saline ground water present in the marine sedimentary rocks that underlie much of the glacial-lake deposits. Upward movement of water from these older sedimentary rocks has affected the quality of water in the underlying unconsolidated aquifers. The ground water in the unconsolidated aquifers of the Copper River lowland is characterized by high concentrations of dissolved solids (up to 10,000 mg/L), sodium, chloride, iron, and manganese.

In many of the coastal areas of Alaska, the natural ground-water quality can be affected by salt-water intrusion.

Because the bedrock aquifers in most of Alaska are undeveloped, very little is known about their water quality. In general, the concentration of dissolved solids in water from bedrock aquifers is higher than found in the unconsolidated aquifers and the chemical quality is more variable.

The most intensive development of bedrock aquifers is in the uplands near Fairbanks (fractured schist). The chemical quality of the water is highly variable and in many cases the presence of high concentrations of several constituents render the water unsuitable or marginal for domestic use. Hardness of ground-water samples from the Fairbanks area ranges from 17 to 1,220 mg/L, and more than 50 percent of sampled wells have a hardness of greater than 200 mg/L. Only 7 percent of the sampled wells have a hardness concentration less than 100 mg/L, a level not considered to be objectionable for most uses. Iron concentrations are also generally high in the Fairbanks area, the known maximum being 26,000 µg/L. Arsenic and nitrate concentrations which exceed the recommended limits for domestic use are common in water from bedrock wells in Fairbanks. The primary source of these constituents and the mechanism by which they enter the ground waters have not been conclusively demonstrated, but they are considered to be most likely from natural rather than man-made sources.

Arsenic concentration ranges from 0 to 10,000 µg/L. In most wells nitrate concentrations are less than 10 mg/L but 21 percent exceeded this value. Mineralized bedrock in the Fairbanks area commonly contains an arsenic-bearing material, arsenopyrite (FeAsS). Scorodite ($FeAsO_4 2H_2O$), a mineral formed by the weathering of arsenopyrite, may also be a source of arsenic within the bedrock.

The vast majority of the State's ground-water resources have, for the present, been unaffected by man. However, in the major urban areas and in some outlying villages ground-water quality has been locally degraded, primarily from septic systems, landfills, and abandoned fuel storage tanks.

The majority of known ground-water contamination cases in the State are caused by petroleum products, primarily from leaky fuel tanks.

SPECIAL NETWORKS AND PROGRAMS

Hydrologic Bench-Mark Network is a network of sites in small drainage basins around the country whose purpose is to provide consistent data on the hydrology, including water quality, and related factors in representative undeveloped watersheds nationwide, and to provide analyses on a continuing basis to compare and contrast conditions observed in basins more obviously affected by the activities of man.

International Gaging Station Network is a network of stations located on the boundary waters between Canada or Mexico and the United States. The stations are officially designated as "International" by joint action of the two countries to provide data pursuant to an international agreement, understanding, or other mutually agreed purposes. Operation of the gaging stations may be by water monitoring agencies of either country, or jointly. Data must be collected and analyzed in a mutually satisfactory manner according to agreed procedures and be available to users in both countries.

National Stream Quality Accounting Network (NASQAN) is a nationwide data collection network designed by the U.S. Geological Survey to meet many of the information needs of government agencies and other groups involved in national or regional water-quality planning and management. These sites are generally located at the downstream ends of hydrologic accounting units designated by the U.S. Geological Survey Office of Water Data Coordination in consultation with the Water Resources Council. The objective of NASQAN is to obtain information on the quality and quantity of water moving within and from the United States through a systematic and uniform process of data collection, summarization, analysis, and reporting such that the data may be used for (1) description of the areal variability of water quality in the Nation's rivers through analysis of data from this and other programs, (2) detection of changes or trends with time in the pattern of occurrence of water-quality characteristics, and (3) providing a nationally consistent data base useful for water-quality assessment and hydrologic research.

Radiochemical Program is a network of regularly sampled water-quality stations where samples are collected to be analyzed for radioisotopes. The streams that are sampled represent major drainage basins.

Tritium Network is a network of stations which has been established to provide baseline information on the occurrence of tritium in the Nation's surface waters. In addition to the surface-water stations in the network, tritium data are also obtained at a number of precipitation stations. The purpose of the precipitation stations is to provide an estimate sufficient for hydrologic studies of the tritium input to the United States.

EXPLANATION OF THE RECORDS

The surface-water and ground-water records published in this report are for the 1989 water year that began October 1, 1988, and ended September 30, 1989. A calendar of the water year is provided on the inside of the front cover. The records contain streamflow data, stage and content data for for lakes and reservoirs, water-quality data for surface and ground water, and ground-water-level data. The locations of the stations and wells where the data were collected are shown in figures 6, 7, and 8. The following sections of the introductory text are presented to provide users with a more detailed explanation of how the hydrologic data published in this report were collected, analyzed, computed, and arranged for presentation.

Station Identification Numbers

Each data station, whether streamsite, lake, reservoir, spring, or well, in this report is assigned a unique identification number. This number is unique in that it applies specifically to a given station and to no other. The number usually is assigned when a station is first established and is retained for that station indefinitely. The systems used by the U.S. Geological Survey to assign identification numbers for surface-water stations and for ground-water well sites differ, but both are based on geographic location. The "downstream order" system is used for regular surface-water stations and the "latitude-longitude" system is used for wells, lakes, reservoirs, springs, and for surface-water stations where only miscellaneous measurements and/or water-quality samples are collected.

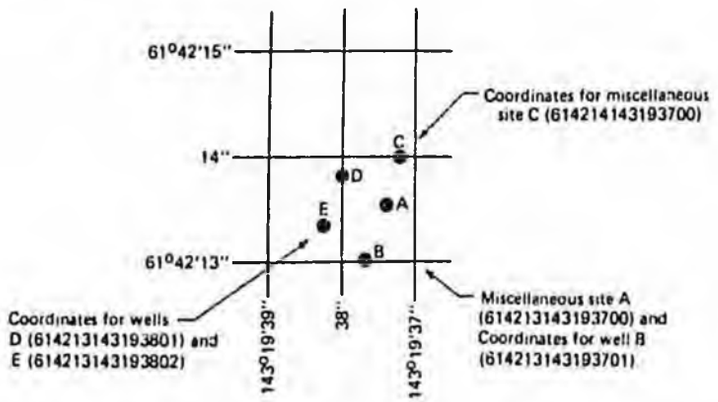
Downstream Order System

Since October 1, 1950, the order of listing hydrologic-station records in Survey reports is in a downstream direction along the main stream. All stations on a tributary entering upstream from a mainstream station are listed before that station. A station on a tributary that enters between two mainstream stations is listed between them. A similar order is followed in listing stations on first rank, second rank, and other ranks of tributaries. The rank of any tributary with respect to the stream to which it is immediately tributary is indicated by an indentation in the "List of Stations" in the front of this report. Each indentation represents one rank. This downstream order and system of indentation show which stations are on tributaries between any two stations and the rank of the tributary on which each station is situated. Stations located on islands in Alaska are in downstream order starting at the most westerly point on the island and moving around the island in a counter-clockwise direction (stations on Kodiak Island start at the most northerly point).

The station-identification number is assigned according to downstream order. In assigning station numbers, no distinction is made between regular stations and partial-record stations; therefore, the station number for a partial-record station indicates downstream-order position in a list made up of both types of stations. Water-quality stations located at or near regular stations or partial-record stations have the same number as the regular or partial-record station. Gaps are left in the series of numbers to allow for new stations that may be established; hence, the numbers are not consecutive. The complete eight-digit number for each station, such as 15303600, which appears just to the left of the station name, includes the two-digit Part number "15" plus the six-digit downstream order number "303600." The Part number designates the state of Alaska.

Latitude-Longitude System

The identification numbers for miscellaneous surface-water sites, wells, springs, lakes, and reservoirs are assigned according to the grid system of latitude and longitude. The number consists of 15 digits. The first six digits denote the degrees, minutes, and seconds of latitude, the next seven digits denote degrees, minutes, and seconds of longitude, and the last two digits (assigned sequentially) identify the wells or other sites within a 1-second grid. This site-identification number, once assigned, is a pure number, and has no locational significance. In the rare instance where the initial determination of latitude and longitude are found to be in error, the station will retain its initial identification number; however, its true latitude and longitude will be listed in the LOCATION paragraph of the station description and also stored in the computerized data base files. See figure below.



System for numbering wells and miscellaneous sites (latitude and longitude).

Local Number

The local number, which is assigned to well and spring sites, is derived in part from the rectangular subdivision of public lands and is used in Alaska as the site name. The first two letters indicate the principal meridian and the quadrant formed by the intersection of the base line and the principal meridian. The first three digits indicate the township in which the well or spring is located, the next three digits the range, and the last two digits the section. The letters following the section number indicate the quarter section, the quarter-quarter section, and so forth to the fourth order subdivision. Each of these subdivisions is lettered counter-clockwise, from the northeast corner. Each site within the smallest order of subdivision is then given a sequential number. Finally, each well within a section is assigned a sequential map number indicated by the last three digits. Thus, SB00601115BCAD1 001 denotes the Seward meridian (S), the northwest quadrant (B), township 6 north, range 11 west, section 15; and the site is in the SE¼ of NE¼ of the SW¼ of the NW¼ (BCAD) of the section. It was the first site in the 2.5 acre "D" subdivision assigned a sequential number (1). The next three digits, 001, indicate the sequence in which a site was located on a map. Thus, 001 indicates the first site plotted in the one-square-mile section. The next space is left blank. The last five digits, such as 00114, are the Alaska register number (which was used prior to 1981) and is provided for continuity with older reports. Therefore, the local number, for sites established prior to 1981 is SB00601115BCAD1001 00114 and the number for sites established in 1981 is SB00601115BCAD1 001. The local number for springs is the same, except for the last three digits and the Alaska register number (assigned to pre-1981 sites), as indicated by the following examples: SB00601115BCAD1S 4065S (pre-1981) and SB00601115BCAD1S (1981 to present). Note: Public-land surveys have not been completed for a large portion of Alaska, therefore, some "local numbers" reflect this in an abbreviated form, i.e., SB00601115.

RECORDS OF STAGE AND WATER DISCHARGE

Records of stage and water discharge may be complete or partial. Complete records of discharge are those at which daily mean discharges can be computed or estimated with reasonable accuracy from the supporting data and information. Because the daily mean discharges commonly are published, the stations are referred to as "daily stations".

By contrast, partial records are obtained through discrete measurements and pertain only to a few flow characteristics, or perhaps only one. The nature of the partial record is indicated by table titles such as "Crest-stage partial records" or "Low-flow partial records". Records of miscellaneous discharge measurements or from special studies, such as low-flow seepage studies, may be considered as partial records, but they are presented separately in this report. Periodic lake-level measurements are also presented separately. Locations of all complete-record and crest-stage partial record stations for which data are given in this report are shown in figures 6 and 7, respectively.

Data Collection and Computation

The base data collected at gaging stations consist of stage records and discharge measurements of streams, and stage of lakes. In addition, observations of factors affecting the stage-discharge relation, weather records, and other information are used to supplement base data in determining the daily flow. Records of stage are obtained from direct readings on a nonrecording gage or from a water-stage recorder that gives either a continuous graph of the fluctuations or a tape punched at selected time intervals. Measurements of discharge are made with a current meter, using the general methods adopted by the Geological Survey. These methods are described in standard textbooks, in Water-Supply Paper 2175, and in U.S. Geological Survey Techniques of Water Resources Investigations, Book 3, Chapter A6.

In computing discharge records, results of individual measurements are plotted against the corresponding stages, and stage-discharge relation curves are then constructed. From these curves, rating tables indicating the approximate discharge for any stage within the range of the measurements are prepared. If it is necessary to define extremes of discharge outside the range of the current-meter measurements, the curves are extended using: (1) logarithmic plotting; (2) results of indirect measurements of peak discharge, such as slope-area or flow-through-culvert measurements and computations of flow-over-dams or weirs; (3) step-backwater techniques; or (4) velocity-area studies.

Daily mean discharges are computed by applying the daily mean stages (gage heights) to the stage-discharge curves or tables. If the stage-discharge relation is subject to change because of frequent or continual change in the physical features that form the control, the daily mean discharge is determined by shifting control method, in which correction factors based on the individual discharge measurements and notes of the person who made the measurement are added (or subtracted) to the gage heights before the discharges are determined from the curves or tables. This shifting-control method also is used if the stage-discharge relation is changed temporarily because of debris or aquatic growth on the control.

In computing records of reservoir contents, it is necessary to have curves or tables defining the relation of stage and contents (from prior survey and computations). The application of stage to stage-content curves or tables gives the contents from which daily, monthly, or yearly changes can be determined. Discharges over lake or reservoir spillways are computed from stage-discharge relations much as other stream discharges are computed. Discharge through hydro-power plants can be calculated indirectly by using the theoretical relation of flow-rates with the amount of power being generated by each turbine, the reservoir level, and the estimated efficiency of each turbine. It is necessary to have tables, curves, or formulas relating the above variables (usually supplied by the manufacturer of the turbine). It is also necessary to have records of reservoir elevation, either from periodic observations or continuous records, and power-generation records (usually furnished by the operators of the power plant).

At most stream-gaging stations in Alaska the stage-discharge relation is affected by ice in the winter, and it becomes impossible to compute the discharge in the usual manner. Discharge for periods of ice effect is computed or estimated on the basis of the available gage-height record and occasional winter discharge measurements. Consideration is given to the available information on temperature and precipitation, notes by gage observers and hydrologists, and comparable records of discharge for other stations in the same or nearby basins.

For some gaging stations there are periods when no gage-height record is obtained or the recorded gage height is so faulty that it cannot be used to compute daily discharge. This happens when the recorder is stopped for the winter or otherwise fails to operate properly, intakes are plugged, the float is frozen in the well, or for various other reasons. For such periods the daily discharges are estimated on the basis of recorded range in stage, prior and subsequent records, discharge measurements, weather records, and comparison with records for other stations in the same or nearby basins. Information explaining how estimated daily-discharge values are identified in station records is included in the next two sections, "Data Presentation" ("REMARKS" paragraph) and "Identifying Estimated Daily Discharge".

Data Presentation

The records published for each gaging station consist of two parts, the manuscript or station description and a data table (or tables) for the current water year. Sometimes data for other than the current year are published, usually to present unpublished data. The manuscript provides, under various headings, descriptive information, such as location of station; drainage area; period of record; average discharge; historical and current-year extremes; record accuracy; and other remarks pertinent to station operation and regulation. The following information, as appropriate, is provided with each continuous record of discharge, stage, or reservoir contents. Comments to clarify information presented under the various headings of the station description follow:

LOCATION.--Information on locations is obtained from the most accurate maps available. The location of the gage with respect to cultural and physical features nearby and to the reference place mentioned in the station name is given.

DRAINAGE AREA.--Drainage areas are measured using the most accurate maps available. Because the type of maps available varies from one drainage basin to another or because of difficulties in determining drainage boundaries, the accuracy of drainage-area determinations likewise varies. As appropriate, some drainage-area figures are qualified by "approximately". Drainage areas are updated as better maps become available.

PERIOD OF RECORD.--This indicates the period for which published records are available for the station or for an equivalent station. An equivalent station is one that was in operation at a time the present station was not, and whose location was such that records from it can be considered reasonably equivalent with records from the current station. Some daily stations were previously operated as partial-record stations or only had monthly discharge records published. These periods are included in the paragraph.

REVISED RECORDS.--Published records occasionally are found to be incorrect, usually because of new information, and revisions are printed in later reports. Listed under this heading are all the reports in which revisions have been published for the station and the water years to which the revisions apply. If a revision did not include daily, monthly, or annual discharge figures, that fact is noted after the year dates as follows: "(M)" means that only the instantaneous maximum discharge was revised; "(m)" that only the instantaneous minimum was revised; and "(P)" that only peak discharges were revised. If the drainage area has been revised, the report in which the most recently revised figure was first published is given.

GAGE.--The type of gage in current use, the datum of the current gage referred to National Geodetic Vertical Datum of 1929 (see "Definiton of Terms"), and a condensed history of the types, locations, and datums of previous gages are given under this heading.

REMARKS.--The paragraph begins by identifying by date all periods of estimated daily-discharge record. (See next section, "Identifying Estimated Daily Discharge".) Other information is also presented such as, accuracy of records, special methods of computation, conditions that affect natural flow at the station, and (if appropriate) other pertinent items. Information about reservoir stations is given on the dam forming the reservoir, the capacity, outlet works and spillway, and purpose (use) of the reservoir. For hydro-power sites, the methods used to compute flow through the turbines and over the spillway are mentioned.

COOPERATION.--Records provided by a cooperating organization or obtained for the Geological Survey by a cooperating organization are identified here. Also, if data or information are supplied which aid in the computation of the record, the agency providing the information is named.

AVERAGE DISCHARGE.--The discharge value shown is the arithmetic mean of the water-year mean discharges. It is computed only for stations having at least 5 water years of complete record, and only water years with complete records are used in the computation. If water developments significantly altering flow at a station are put into use after the station has been in operation for a period of years, and sufficient information or data are available, the average is adjusted to give the natural flow at the site. However, if not enough information is available, a new average is computed as soon as 5 water years have accumulated following the development.

EXTREMES FOR PERIOD OF RECORD.--Extremes may include maximum and minimum discharges, stages, or contents. Unless otherwise qualified, the maximum discharge or contents is the instantaneous maximum corresponding to the highest stage that occurred. The highest stage may have been obtained from a graphic or digital recorder, a crest-stage gage, direct observation of a nonrecording gage, or from high-water marks. If the maximum stage did not occur on the same day as the maximum discharge, it is shown separately. Similarly, the minimum is the instantaneous minimum discharge, unless otherwise qualified.

EXTREME OUTSIDE PERIOD OF RECORD.--Information about floods or unusually low flows that have occurred outside the stated period of record is included. The information may or may not have been obtained by the U.S. Geological Survey.

EXTREMES FOR CURRENT YEAR.--The contents of this paragraph are similar to those in "PERIOD OF RECORD", except that a peak discharge list with secondary peaks may be given. For records that meet certain criteria, all peak discharges and stages greater than a selected base discharge during the water year are given. The peaks greater than the base discharge, excluding the highest one, are called secondary peaks. The time that the peak occurred is expressed in 24-hour local standard time; for example, 12:30 a.m. is 0030 and 1:30 p.m. is 1330. The minimum for the current water year appears below the table of peak data.

REVISIONS.--If a critical error in published records is discovered, a revision is included in the first report published following discovery of the error.

The daily table for stream-gaging stations gives the mean discharge for each day and also monthly and yearly summaries. In the monthly summary below the daily table, the line headed "TOTAL" gives the sum of the daily figures. The line headed "MEAN" gives the average flow in cubic feet per second during the month. The lines headed "MAX" and "MIN" give the maximum and minimum daily discharges, respectively, for the month. Discharge for the month also may be expressed in acre-feet (line headed "AC-FT"), in cubic feet per second per square mile (line headed "CFSM"), or in inches (line headed "IN"). Figures for cubic feet per second per square mile and runoff in inches are omitted if there is extensive regulation or diversion, if the contributing drainage area or boundaries are unknown, or if the flow is mostly from a spring. In the yearly summary below the monthly summary, the figures shown are the appropriate daily discharges for the calendar and water years. At some stations, monthly and (or) yearly discharges are adjusted for diversions or changes in reservoir contents.

Data collected at partial-record stations follow the information for continuous-record sites. A table of crest-stage partial-record stations is followed by a listing of discharge measurements made at sites other than continuous-record or partial-record stations. In prior years, low-flow partial-record stations have been published, but none were in operation in the current water year. Occasionally, a series of discharge measurements are made within a short time period to investigate the seepage gains or losses along a reach of a stream or to determine the low-flow characteristics of an area. Such measurements are also given in special tables following the listing of miscellaneous measurements. Lake-level data collected at miscellaneous selected lakes are also tabulated.

Identifying Estimated Daily Discharge

Estimated daily-discharge values in the current annual data report are identified by listing the dates of the estimated record in the "REMARKS" paragraph of the station manuscript. Prior to the report for the 1985 water year, estimated daily-discharge values were not specifically identified.

Accuracy of the Records

The accuracy of streamflow data depends primarily on: (1) the stability of the stage-discharge relation or, if the control is unstable, the frequency of discharge measurements; and (2) the accuracy of observations of stage, measurements of discharge, and interpretations of records.

The station description under "REMARKS" states the degree of accuracy of the records. "Excellent" means that about 95 percent of the daily discharges are within 5 percent of the true value; "good" within 10 percent; and "fair" within 15 percent. Records are rated as "poor" when they do not meet the criteria above. Different accuracies may be attributed to different parts of a given record.

Figures of daily mean discharge in this report are shown to the nearest hundredth of a cubic foot per second for discharges of less than 1 ft^3/s; to the nearest tenth between 1.0 and 10 ft^3/s; to whole numbers between 10 and 1,000 ft^3/s; and to 3 significant figures above 1,000 ft^3/s. The number of significant figures used is based solely on the magnitude of the discharge value. The same rounding rules apply to discharges listed for partial-record stations and miscellaneous measurement sites.

Discharge at many stations, as indicated by the monthly mean, may not reflect natural runoff due to the effects of diversion, flow from springs, or to other factors. For such stations, figures of cubic feet per second per square mile and of runoff in inches are not published unless satisfactory adjustments can be made for diversions or for other factors that might affect the flows. At those stations where adjustments are made, large errors in computed runoff may occur if adjustments are large in comparison to observed discharge. Evaporation from a reservoir is not included in the adjustments for changes in reservoir contents.

Other Data Available

Information of a more detailed nature than that published for most of the gaging stations such as observations of water temperatures, discharge measurements, gage-height records, and rating tables, is filed in the subdistrict offices at Anchorage, Fairbanks, and Juneau for their areas of responsibility. Also, most of the daily mean discharges are in computer files and can be retrieved for statistical analyses. Information on the availability of unpublished data or statistical analyses may be obtained from the district office.

RECORDS OF SURFACE-WATER QUALITY

Records of surface-water quality ordinarily are obtained at or near stream-gaging stations because interpretation of records of surface-water quality nearly always requires corresponding discharge data. Records of surface-water quality in this report involve a variety of types of data and measurement frequencies.

Classification of Records

Water-quality data for surface-water sites are grouped into one of three classifications. A continuing-record station is a site where data are collected on a regularly scheduled basis. Frequency may be once or more times daily, weekly, monthly, or quarterly. A partial-record station is a site where water-quality data are collected systematically over a period of years. Frequency of sampling is usually less than quarterly. A miscellaneous sampling site is a location other than a continuing or partial-record station, where random samples are collected to give better areal coverage to define water-quality conditions in the river basin.

A distinction needs to be made between "continuing records" as used in this report and "continuous recordings," which refers to a continuous graph or a series of discrete values punched at short intervals on a paper tape. Some records of water quality, such as temperature and specific conductance, may be obtained by continuous recordings; however, because of costs, most data are obtained only monthly or less frequently.

Arrangement of Records

Water-quality records collected at a surface-water daily record station are published immediately following that record, regardless of the frequency of sample collection. Station number and name are the same for both records. Where a surface-water daily record station is not available or where the water quality differs significantly from that at the nearby surface-water station, the continuing water-quality record is published with its own station number and name in the regular downstream-order sequence. Water-quality data for partial-record stations and for miscellaneous sampling sites appear in separate tables following the table of discharge measurements at miscellaneous sites.

On-Site Measurements and Sample Collection

To assure the data obtained represent the in situ quality of the water, certain measurements, such as water temperature, pH, alkalinity, and dissolved oxygen, are made onsite when the samples are collected. To assure that measurements made in the laboratory also represent the in situ water, prescribed procedures are followed in collecting, treating, and shipping the samples to prevent changes in quality pending analysis in the laboratory. These procedures are given in publications on "Techniques of Water-Resources Investigations", Book 1, Chap. D2; Book 3, Chap. C2; Book 5, Chap. A1, A3, and A4.

One sample can adequtely define the water quality at a given time if the mixture of solutes throughout the stream cross section is homogeneous. However, the concentration of solutes at different locations in the cross section may vary widely with different rates of water discharge, depending on the source of material and the turbulence and mixing of the stream. Some streams must be sampled through several vertical sections to obtain a representative sample needed for an accurate mean concentration and for use in calculating load.

Chemical-quality data published in this report are considered to be the most representative values available for the stations listed. The values reported represent water-quality conditions at the time of sampling as much as possible, consistent with available sampling techniques and methods of analysis. In the rare case where an apparent inconsistency exists between a reported pH value and the relative abundance of carbon dioxide species (carbonate and bicarbonate), the inconsistency is the result of a slight uptake of carbon dioxide from the air by the sample between measurement of pH in the field and determination of carbonate and bicarbonate in the laboratory.

Water Temperature

Water temperatures are measured at most of the water-quality stations. In addition, water temperatures are taken at time of discharge measurements for water-discharge stations. Large streams have a small diel temperature change; shallow streams may have a daily range of several degrees and may follow closely the changes in air temperature. Some streams may be affected by waste-heat discharges.

At stations where recording instruments are used, maximum and minimum temperatures for each day are published. Water temperatures measured at the time of water-discharge measurements are on file in the District office.

Sediment

Suspended-sediment concentrations are determined from samples collected by using depth-integrating samplers. Samples usually are obtained at several verticals in the cross section, or a single sample may be obtained at a fixed point and a coefficient applied to determine the mean concentration in the cross sections.

During periods of rapidly changing flow or rapidly changing concentration, samples may have been collected more frequently (twice daily or, in some instances, hourly). The published sediment discharges for days of rapidly changing flow or concentration were computed by the subdivided day method (time-discharge weighted average). Therefore, for those days when the published sediment discharge value differs from the value computed as the product of discharge times mean concentration times 0.0027, the reader can assume that the sediment discharge for that day was computed by the subdivided day method. For periods when no samples were collected, daily loads of suspended sediment were estimated on the basis of water discharge, sediment concentrations observed immediately before and after the periods, and suspended-sediment loads for other periods of similar discharge.

At other stations, suspended-sediment samples were collected periodically at many verticals in the stream cross section. Although data collected periodically may represent conditions only at the time of observations, such data are useful in establishing seasonal relations between quality and streamflow in predicting long-term sediment-discharge characteristics of the stream.

In addition to the records of the quantities of suspended sediment, records of the periodic measurements of the particle-size distribution of the suspended sediment and bed material are included.

Laboratory Measurements

In March 1989 the National Water-Quality Laboratory discovered a bias in the turbidimetric method for sulfate analysis, indicating that values below 7.3mg/L have a median positive bias of 2mg/L above the true value for the period between 1982 and 1989. Sulfate values in this report have not been corrected for this bias.

Sediment concentration and sand-break samples are analyzed locally; all other sediment samples are analyzed in the U. S. Geological Survey laboratory in Iowa City, Iowa. Methods used in analyzing sediment samples and computing sediment records are given in TWRI, Book 5, Chap. C1. Methods used by the Geological Survey laboratory are given in TWRI, Book 1, Chap. D2; Book 3, Chap. C2; Book 5, Chap. A1, A3, and A4.

RECORDS OF GROUND-WATER LEVELS

Only ground-water level data from a basic network of observation wells are published in this report. This basic network consists of observation wells located in the most important aquifers, and therefore the most significant data are obtained from the fewest wells. (See figure 8.)

Data Collection and Computation

Water-level measurements are made in many types of wells, under varying conditions of access and weather conditions. However, the equipment and measuring techniques used at each observation well assure that the measurements are of consistent accuracy and reliability.

Tables of water-level data are presented by Hydrologic Subregion. The station-identification number for a given well is the 15-digit number that appears in the upper left corner of the station description. The secondary identification number is the local number, an alphanumeric number, derived from the township-range location of the well.

Water-level records are obtained from direct measurements with a steel tape or from the graph or punched tape of a water-stage recorder. The water-level measurements in this report are given in feet with reference to either National Geodetic Vertical Datum of 1929 (NGVD of 1929) or land-surface datum (lsd). NGVD of 1929 is the datum plane on which the national network of precise levels is based; land-surface datum is a datum plane that is approximately at land surface at each well. If known, the altitude of the land-surface datum is given in the well description. The height of the measuring point (MP) above or below land-surface datum is also given in each well description. Water levels in wells equipped with recording gages are reported for every fifth day and the end of each month (eom). Daily water levels are reported for a few wells that may have significant fluctuations between every fifth day. The extreme water levels recorded during the year are reported as the highest water level (HIGH) and as the lowest water level (LOW).

Water levels are reported to as many significant figures as can be justified by the local conditions. For example, in a measurement of a depth to water of several hundred feet or if an electric water sensor is used, the error in determining the absolute value of the total depth to water may be a few tenths of a foot. However, the error in determining the net change of water level between successive measurements may be only a hundredth or a few hundredths of a foot. For lesser depths to water, the accuracy is greater. Accordingly, most measurements are reported to a hundredth of a foot, but some are given only to a tenth of a foot.

Data Presentation

Each well record consists of two parts: the station description and the data table of water levels observed during the water year. The description of the well is presented first through use of descriptive headings preceding the tabular data. Clarification of each heading is given below.

LOCATION.--This paragraph follows the well-identification number and reports the latitude and longitude (given in degrees, minutes, and seconds); the Hydrologic Unit; the distance and direction from a geographic point of reference; and the owner's name.

AQUIFER.--This entry designates by name (if a name exists) and geologic age the aquifer(s) open to the well.

WELL CHARACTERISTICS.--This entry describes the well in terms of depth, diameter, casing depth and/or screened interval, method of construction, and additional information such as casing breaks, collapsed screen, and other changes since construction.

INSTRUMENTATION.--This paragraph provides information on both the frequency of measurement and the collection method used, allowing the user to better evaluate the reported water-level extremes by knowing whether they are based on weekly, monthly, or some other frequency of measurement.

DATUM.--This entry describes both the measuring point and the land-surface elevation at the well. The measuring point is described physically (such as top of collar, notch in top of casing, plug in pump base and so on), and in relation to land surface (such as 1.3 ft above land-surface datum). The elevation of the land-surface datum is described in feet above (or below) National Geodetic Vertical Datum of 1929 (NGVD of 1929); it is reported with a precision depending on the method of determination.

REMARKS.--This entry describes factors that may influence the water level in a well or the measurement of the water level. It should identify wells that also are water-quality observation wells, and may be used to acknowledge the assistance of local (non-survey) observers.

PERIOD OF RECORD.--This entry indicates the period for which there are published records for the well. It reports the month and year of the start of publication of water-level records by the the U. S. Geological Survey and the words "to current year" if the records are to be continued into the following year. Periods for which water-level records are available, but are not published by the U. S. Geological Survey, may be noted.

EXTREMES FOR PERIOD OF RECORD.--This entry contains the highest and lowest water levels of the period of published record, with respect to land-surface datum, and the dates of their occurrence.

A table of water levels follows the station description for each well. Water levels are reported in feet below land-surface datum and all taped measurements of water levels are listed. For wells equipped with recorders, only abbreviated tables are published; generally, only water-level lows are listed for every fifth day and at the end of the month (eom). The highest and lowest water levels of the water year and their dates of occurrence are shown on a line below the abbreviated table. Because all values are not published for wells with recorders, the extremes may be values that are not listed in the table. Missing records are indicated by dashes in place of the water level.

RECORDS OF GROUND-WATER QUALITY

Records of ground-water quality in this report differ from other types of records in that for most sampling sites they consist of only one set of measurements for the water year. The quality of ground water ordinarily changes slowly; therefore, for most general purposes one annual sampling, or a few samples taken at infrequent intervals during the year, is sufficient. Frequent measurement of the same constituents is not necessary unless one is concerned with a particular problem, such as monitoring for trends in nitrate concentration. In special cases where the quality of ground water may change more rapidly, more frequent measurements are made to identify the nature of the changes.

Data Collection and Computation

The records of ground-water quality in this report were obtained mostly as a part of special studies in specific areas. Consequently, a number of chemical analyses are presented for some areas but none for other areas. As a result, the records for this year, by themselves, do not provide a balanced view of ground-water quality Statewide. Such a view can only be attained by considering records for this year in context with similar records obtained for these and other areas in earlier years.

Data Presentation

The records of ground-water quality are published in a section titled QUALITY OF GROUND WATER immediately following the ground-water-level records. Data for quality of ground water are listed by Hyrologic Subregion, and are identified by well number. The station-identification number for wells sampled is the 15-digit number derived from the latitude-longitude locations. No descriptive statements are given for ground-water-quality records; however, the well number, depth of well, date of sampling, and other pertinent data are given in the table containing the chemical analyses of the ground water.

ACCESS TO WATSTORE DATA

The National WATer Data STORage and RETrieval System (WATSTORE) was established for handling water data collected through the activities of the U.S. Geological Survey and to provide for more effective and efficient means of releasing the data to the public. The system is operated and maintained on the central computer facilities of the Survey at its National Center in Reston, Virginia.

WATSTORE can provide a variety of useful products ranging from simple data tables to complex statistical analyses. A minimal fee, plus the actual computer cost incurred in producing a desired product, is charged to the requester. Information about the availability of specific types of data, the acquisition of data or products, and user charges can be obtained locally from each of the Water Resources Division's District offices (see address given on the back of the title page).

General inquiries about WATSTORE may be directed to:

Chief Hydrologist
U.S. Geological Survey
437 National Center
Reston, Virginia 22092

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Dispatch

THE WATER PROFITEERS

In the thirsty West, precious groundwater is luring rich new owners.

by PETER STEINHART

COLORADO'S SAN LUIS Valley is almost as flat as a pan, eighty miles wide and a hundred long. The Sangre de Cristo Mountains rise steeply from the eastern edge of the valley, and the San Juans form its western wall. The Rio Grande trickles out of the San Juans, meanders past Alamosa, and wanders through the sage and sand and rabbit brush into New Mexico. Clouds form over the mountain rims every summer afternoon, but the sky directly over the valley remains as blue as an oyster's dream. It rains only seven inches a year on the valley floor, a pluvial stinginess that qualifies the place as a desert. But the mountains ringing the valley have for millions of years collected rainfall and snowmelt which percolate into the ground and run down into the valley's deep alluvial gravels. Here and there it bubbles up on the valley floor in springs and artesian wells. Farmers have sunk 3,000 wells and drawn from the earth prosperous grain and potato farms. There are 1,800 large pivot-irrigation systems in the valley, one of the densest concentrations in the world. Under the San Luis Valley may be two billion acre-feet of groundwater, an aquifer as rich and wet as the Ogallala Aquifer which for a century has irrigated Nebraska, Kansas, and Oklahoma.

Coloradans have long fought over such water. In dry years wells and irrigation ditches dry up; a farmer who sees his crop die in the field may deepen his well or siphon more water than he is entitled to from the ditch, and his neighbor may shoot him or call the sheriff. In the 1950s the Park County water commissioner was found dead at the bottom of a well, and for the next four years no one could be persuaded to serve as water commissioner. In the early 1980s a speculator named John Houston laid claim to all of Colorado's groundwater, and was stopped in his scheme only by a state supreme court ruling. About the same time a Texas company tried to buy up land in the San Luis Valley, planning to export the water to Texas.

On December 31, 1986, American Water Development Incorporated (AWDI), the new owners of the 155,000-acre Baca Ranch in the San Luis Valley, applied for rights to drill ninety-seven new wells and pump as much as 200,000 acre-feet of water a year. (An acre-foot is the amount of water it would take to flood an acre of land a foot deep—roughly the amount of water in a municipal swimming pool.) That water, quite clearly, would not be used to irrigate lands in the San Luis Valley. It would be exported over Poncha Pass to support future urban growth in the Front Range cities of Denver and Colorado Springs.

The idea of such a development defies a deeply ingrained belief that water, like air, is everybody's birthright—that it is impulsive but free and dependable. Despite the reality that water and profit are the same word in the West, despite the fact that everybody pays for water, our culture grew up in wetter places; in our minds, our water and someone else's money don't mix. Says Michael Entz, who grows wheat, barley, and potatoes on seven pivot-irrigation circles near the Baca Ranch, "You have somebody coming here to export your resource and try to turn a big profit. It's yours and somebody is trying to take it from you."

Mike Entz's father and grandfather farmed the valley before him. In a good year the groundwater he pumps from wells accounts for about thirty percent of his costs. Over the years the water table in his area has dropped from five feet below the surface of the ground to eighty feet below, and each additional foot his pumps must lift the water costs more. The deeper the water table drops, the more likely the water will contain salts and minerals that are toxic to crops. And there are two aquifers, a shallow one and a deeper one, separated by a layer of blue clay. The deeper one is believed to feed the Rio Grande. When wells draw down the lower aquifer, the State of Colorado restricts pumping in the San Luis Valley to meet its obligations under the Rio Grande Compact, an interstate agreement to deliver water through the Rio Grande to New Mexico and Texas.

Because the state engineer, who is the director of the Colorado Division of Water Resources, believes all the water is allotted, farmers cannot get permission to deepen their wells. So, if AWDI exports water from the valley, the farmers fear they will get poorer-quality water, pay more for it, and pos-

sibly be left without water at all. A study done at the request of the San Luis Valley Water Conservancy District estimated that the cost of water from deeper wells would be $50 to $80 an acre-foot in the shallow aquifer, $210 to $370 an acre-foot in the deeper aquifer, but concluded: "Realistically, the highest cost a valley farmer can pay is about twenty dollars an acre-foot." Says a farmer in the H & R Supply Store in Center, "It will put us out of business."

It could also have dire consequences for the natural environment. That water once fostered broad wetlands and waterfowl populations. Today there are two national wildlife refuges, four Bureau of Land Management wildlife areas, and a handful of state wildlife areas in the valley, and all of them might be affected by the AWDI withdrawals. Mel Nail, former manager of the Alamosa and Monte Vista national wildlife refuges, fears that AWDI withdrawals will leave less water in the Rio Grande, and so reduce the amount of water available to the refuges. Says Nail, "I'm sure it will just shut off the water to BLM's Blanca Wildlife Habitat Management Area."

AWDI didn't file for rights to the water until the Bureau of Reclamation had condemned 38,000 acres of the Baca Ranch for wells and pipelines under the Closed Basin Project, a scheme which pumps shallow aquifer water into the Rio Grande to meet Colorado's interstate compact obligations. BuRec claims 80 percent of the water is salvaged from plants which suck it from the shallow water table and transpire it into the air. By pumping the top two feet off the aquifer, the bureau expected to meet the needs of farmers, the compact, and wildlife. But once the bureau began to pump Baca Ranch groundwater, AWDI feared others would invoke the western water doctrine that water not being put to beneficial use can be appropriated, and make claims on its water. So AWDI filed for its own rights. At first AWDI hoped to use the water in the valley to grow barley and perhaps support a brewery. But that proved uneconomical. "The only econornical way to get rid of this water is to sell it," says Steve Vandiver, the district engineer. And having been freshly disappointed in its desires to build Two Forks Dam, the Denver metropolitan area "will have to look at other places for a water supply," Vandiver says. "They're not shy in seeking water supplies wherever they can get them."

The San Luis Valley is not a wealthy place. Says Vandiver, "As a whole, the San Luis Valley is starving to death." Its southern counties are among the poorest in the nation. "There isn't anything to keep people here but agriculture, and agriculture is on the ropes. The kids are going to Denver and becoming computer operators." In the face of the valley's poverty, the rhetoric of AWDI has not been reassuring.

Baca Ranch general manager Buddy Whitlock says, "If the farmers are using 1.2 million acre-feet of water and this valley is still poor, that's not really the maximum beneficial use of the water." He tells of a local banker who confided to him, "It simply does not make any sense to put three acre-feet of water that's worth two thousand to seven thousand dollars an acre-foot on an acre of pasture to grow one hundred fifty pounds of beef."

It might be easier to envision this as a war between open-handed farmers in the valley and vault-paled investors from Wall Street. But in this newly urbanizing West, it gets harder and harder to tell who the good guys are. AWDI is a consortium of eastern and western corporate investors. But the board of directors includes Richard Lamm, formerly the governor of Colorado, and William Ruckelshaus, formerly administrator of the Environmental Protection Agency. The chairman of the board, until recently, was Maurice Strong, formerly head of the United Nations Environment Programme.

For his part, Strong declared that AWDI would work to "guarantee that nobody is damaged, within the limits of our supply." If farmers had to deepen their wells, he said, "we would compensate them for additional costs." He said that "the wetlands must be protected." He declared, "If we cannot pass the environmental tests and protect the valley interests, I would not want to continue with the project."

But the thirst for water in the West is insistent and growing. "If we walked away tomorrow," Strong conceded, "there would be ten others lining up to do it." Valley farmers do not trust AWDI. They and environmental agencies are fighting AWDI's application for water rights. Currently challenging AWDI are the Rio Grande Water Conservation District, the Colorado state engineer, the Colorado Division of Wildlife, the Bureau of Reclamation, the Bureau of Land Management, the U.S. Fish and Wildlife Service, the National Park Service, and a host of water districts and municipalities. Altogether more than thirty groups have gone to court against AWDI.

"To achieve a nice patchwork-quilt effect, I think fields 1, 3, 5, 7, and 9 should be planted horizontally with barley, alfalfa, corn, rye, and cabbage while fields 2, 4, 6, 8, and 10 should be planted vertically with oats, soybeans..."

WHAT IS GOING ON in the San Luis Valley is going on here and there all over the arid Southwest, where a growing urban population has arrived after farmers plugged up all the good dam sites and after the federal government stopped cheerfully building irrigation projects to subsidize farmers. In the West, water distribution is based upon appropriative rights. The first one using the water gets it, and his claims are defended by the courts from subsequent claims by later arrivals. The oldest rights are senior in times of drought. Rarely is anything left in the streambed for fish or wildlife. Since midcentury, the cities have more than doubled in population, and they are expected to add nearly fifty percent to their current numbers by the year 2020. But there is no water lying around for easy appropriation.

"The era of finding a new water hole is largely gone," says former Arizona Governor Bruce Babbitt. "There's no federal money. The Department of the Interior is brain dead. And as a result of that we will have the opportunity to take the future in our hands."

We have entered what Santa Fe water-policy consultant Steve Shupe calls "an era of reallocation." Marketing water that has already been allocated is increasingly being viewed as a substitute for new government-subsidized dams. Irrigation districts have long traded water among themselves. In California's San Joaquin Valley, for example, the 9,500-acre Broadview Water District recycles agricultural drainwater and sells some of the freshwater it buys from the Bureau of Reclamation to neighboring irrigation districts. What is new in this age of reallocation is that urban centers are vying with agricultural areas for the water. And since urban users are willing to pay much more for water than farmers can pay, the cities are winning.

Arizona uses twice the water it receives in surface runoff; groundwater is the chief water supply for the state and it is mined at rates that promise ultimate exhaustion. In 1980 Arizona forbade additional groundwater withdrawals around the cities of Phoenix and Tucson and required them to have a hundred-year supply of water for any further development. The intention was to stop overdrafting the groundwater. The solution was the free market. Says Bruce Babbitt, who as governor presided over the drafting of the law, "We deliberately drafted a provision that said groundwater will be freely transferable. We said, 'Let the market reign.' As a result, we triggered a rush to the Owens Valley. There were guys in black hats from Phoenix and Tucson roaming the backwoods of the state with open checkbooks." Phoenix, Tucson, Mesa, and Scottsdale acquired more than 50,000 acres of farms with the intention of retiring the fields, pumping the groundwater into the Central Arizona Project aqueduct, and delivering it to household taps nearly one hundred miles away.

Along Colorado's Front Range, municipalities have been buying up ditch companies and shares of stock in water supplies. The City of Aurora, a suburb of Denver, purchased a major irrigation ditch east of Pueblo, along the Arkansas River, and transferred the water to its municipal lines. Thornton, Colorado, secretly spent $52 million buying up options and title to 20,000 irrigated acres in the Cache la Poudre River Basin.

In Utah, fast-growing Salt Lake City suburbs like Sandy City, South Jordan, West Valley City, and Bountiful came late to the trough, and are now seeking to buy older water rights. With their thirst in mind, the Salt Lake County Water Conservancy District is negotiating the purchase of rights to 40,000 acre-feet of water per year, water that now goes to farms. St. George, in southern Utah, is buying up irrigation rights to slake the thirst of a growing retirement community. Utah cities have acquired rights to more than 100,000 acre-feet of water by buying up shares of canal and ditch companies.

Around Reno, Nevada, municipalities and the local electric utility are buying up water rights to secure future development. Las Vegas has a standing offer to purchase water rights for $1,000 per acre-foot. The water agency for Castaic Lake, a rapidly urbanizing area north of Los Angeles, purchased land at Devils Den in the San Joaquin Valley and plans to transfer its water.

With the avid interest of municipalities, private brokers have gotten into the act. More than a decade ago a major insurance company bought shares of Colorado irrigation water and resold them for profit to Front Range cities. More recently, two Prudential-Bache investment funds bought more than $42 million worth of western water rights, intending to hold onto them for up to fifteen years before selling. William McLemore, a Colorado water

broker, says he has put together more than $100 million in water deals in the past five years. Says Walraven Ketellapper of Stillwater Resources, a Denver investment firm, "I know one speculator who is holding 100,000 acre-feet, intending to sell it to the Denver area." Oil companies which purchased water rights in the 1970s for oil-shale developments are now holding onto those rights in the expectation they will increase in value. Ketellapper believes oil companies hold rights to as much as 400,000 acre-feet in Colorado alone. Says Steve Shupe, "There are a number of entrepreneurs knocking on the door of San Diego every week with a scheme to take water from Colorado and pipe it to San Diego." A Phoenix-area consortium, Agricom, purchased more than 30,000 acres in La Paz County, nearly a hundred miles away, expecting to use more than 100,000 acre-feet of groundwater a year in Phoenix land developments. Lincoln Savings, the Arizona savings and loan company run by Charles Keating, purchased 13,000 acres of farmland in La Paz County.

Increasingly, water is finding new owners. A study by researchers at the University of Arizona found that in the last twelve years there were about 6,000 transactions in Utah, 1,455 in New Mexico, 1,500 in Colorado. A 1985 study showed that half the available blocks of more than ten acre-feet of water around Reno were held by developers and half by owners waiting for higher bids. In Reno private brokers outbid the public agencies, repackage the rights, and sell them to developers for three times more than the agencies will pay. In Park City, Utah, rights were bought by a resort developer for $10,000 an acre-foot. With prices like that, farmers often inflate the value of their own water rights. Says Ketellapper, "In Colorado you might ask a farmer, 'What do you want for your water?' and he'll say twenty-five hundred dollars an acre-foot. You might then say, 'What do you want for your ranch?' and he might say half of that."

The trend makes farming communities nervous. They remember what happened to California's Owens Valley after the City of Los Angeles bought up its water rights. Los Angeles bought up 75 percent of the agricultural lands and most of the urban real estate in the valley. In 1920 there were 140,000 irrigated acres on 521 farms in the valley. By 1950 only 30,000 acres remained, and the total declined to less than 5,000 during drought years. Today there are only a handful of commercial farms. Los Angeles and state and federal agencies own over 99 percent of Inyo County. "Because Los Angeles owns all the land in the valley, there's no opportunity for growth," says Greg James, Inyo County Water Department director. Inyo County and Los Angeles have sued each other back and forth, and they are still suing one another to determine who controls the valley's groundwater.

Residents of La Paz County, Arizona, fear they may be headed toward the same fate. Ninety-five percent of the land in La Paz County is federally owned, and therefore off the tax rolls. Half the remaining private lands have been bought by Arizona municipalities and speculators, "and that fifty percent of the land represents one hundred percent of the groundwater in the county," says Gene Fisher, chairman of the La Paz County Board of Supervisors. Under Arizona law, municipally held lands are exempt from taxes, so the county's tax base has shrunk and its ability to sell bonds has declined. Says Fisher, "The perception is out there that La Paz County is not a place where people would like to move and live and start a new industry."

Forty miles east of Pueblo, Colorado, 50,000 acres of irrigated Arkansas Valley farmland has already been retired by cities. Fifteen percent of the water formerly used in the valley has been moved to the cities. "That is wrecking the economy of the valley," says Frank Milenski, a seventy-six-year-old La Junta farmer. Milenski's family has grown alfalfa, onions, cantaloupes, corn, tomatoes, watermelons, peppers, and beans since the 1930s. Recently he has seen neighbors move off 4,000 acres of farmlands bought by the City of Aurora. Car dealerships and farm equipment stores have closed down. Neighboring Crowley County begged for a new maximum-security prison to compensate for the loss of water. "They keep wanting to gather it up and gather it up," says Milenski, "and the rural areas don't have much representation anymore. It's an undesirable situation."

Chuck Howe, a University of Colorado economist, has studied the effects of water transfers on the Arkansas Valley. He concludes, "What we're getting is a phasing out of marginal lands, lands whose agricultural production has been low." He believes it is the lands that grow less-profitable crops,

like alfalfa, pasture, and small grains, that go out of production. If a farm that grows cantaloupes or onions or tomatoes goes out, a neighbor is likely to see a market opportunity opening and switch from alfalfa to the more profitable crops. "Preliminary runs indicate the economic impact of the phaseout of 50,000 acres is really minimal," says Howe. He says the economy is changing anyway. "The area has been under strain for decades."

There were once at least fifteen sugar mills in the valley, but all had closed before the water transfers. "Young people have been moving out for thirty or forty years," says Howe. "You have an extraordinarily large percentage of welfare payments and retirement income in the valley." Howe guesses that as much as 20,000 acres more could go out of production, most of that now in pasture and small grains that support the valley's livestock industry. That would make the livestock operations "noncompetitive" and probably eliminate a quarter of the agricultural employment in the valley. Even then, says Howe, "the impacts on the state economy are pretty trivial."

"Sure the Arkansas Valley doesn't make a pimple on the whole damn business," says Milenski. "But it's a way of life and a damn good one. You look at Denver: Them bastards all get in a pile up there. You got smog all the time. I don't know why they couldn't bring the industry where the water is. It makes more sense to me."

ENVIRONMENTALISTS and city water users have long pitted themselves against farmers in the West's water battles. They argue that while 85 percent or more of western water goes to agriculture, the farms contribute a disproportionately small benefit to the states' economies as a whole. For example, California advocates of water marketing point out that four crops—cotton, rice, alfalfa, and pasture—account for 45 percent of the state's total water use but provide only three-thousandths of one percent (.003 percent) of the state's economic return. City customers pay $250 or more per acre-foot of water, while farmers pay as little as $3.50 per acre-foot. By selling their water to cities instead of growing alfalfa or hay, the farmers might make even more money.

But at the same time it might put local seed, fertilizer, and equipment dealers out of business and thereby make life harder on those farmers who chose not to sell their water. Oregon recently passed a law requiring the State Department of Water Resources to take into account the needs of an area before water can be transferred out of it. Because of what Los Angeles did to the Owens Valley, California laws now require state and federal water projects to consider the local effects of withdrawals. But protections are not specified: Should there be a limit on how much water can be withdrawn? Ought the importing agencies to pay the counties of origin some in-lieu-of-tax payments and other compensations? Ought there to be severance taxes, such as are applied to timber, coal, or petroleum? When the Arizona Legislature wrestled with these questions last year, the rural counties felt the groundwater bill under consideration did not give them enough protections and defeated it.

One solution to the problem may be to allow farmers to sell their water without selling their water rights, in effect making them water ranchers. In Colorado there are thought to be more than a hundred active water ranches, farms whose owners intend to mine the water rather than the grass or soil. Franklyn Jeans, a Reno entrepreneur, bought a cattle ranch in Nevada for $2

million and found it much less valuable for its range than for its water, which he believes will be worth $120 million delivered to the Reno area. Since 1986 California's city-minded legislature has passed laws allowing transfers from the State Water Project, requiring irrigation districts to allow their canals to be used to move third-party water, and recognizing water transfers as beneficial uses so as to protect the long-term rights of districts and farmers who lease water to thirsty cities. The new laws were propelled in part by a deal inspired by the Environmental Defense Fund, under which the Metropolitan Water District (which provides water to 15 million Southern Californians) is paying to line Imperial Irrigation District canals and automate parts of its delivery system, and in turn each year will collect 100,000 acre-feet of water thus conserved. In 1989 the Yuba County Water Agency, finding its reservoir full when other parts of the state had experienced a drought, sold water to the urban Santa Clara Valley Water District. And the Metropolitan Water District has been negotiating with other water districts to purchase dry-year options, under which in dry years MWD would pay farmers even more than their crops would bring to idle their lands and sell the cities their water.

But farmers are reluctant to sell even dry-year options. When the Berrenda Mesa Water District in California's Kern County sought to market water that some of its own farmers couldn't afford to buy, the county declared it illegal to transfer water out of the county. Kern, California's biggest farming county, has seen farmed acreage drop from 970,000 to 850,000 acres in the last fifteen years, but water officials there want to see any surplus water put into the ground to retire a 300,000-acre-foot overdraft.

State laws often make it illegal to transfer water very far. Texas outlaws interbasin transfers. New Mexico has tried to outlaw out-of-state transfers. When a Wyoming rancher decided he could make more money letting his water run into the Colorado River and selling his entitlements to a California city, the State of Wyoming—fearing the loss of the tax revenues that water might generate, and fearing a rush of other low-profit farms to the lucrative California water market—forbade him to sell his water out of the state.

Farmers fear that, under the western water doctrine of "use it or lose it," if they don't put the water on their fields they might lose their entitlement to it. Many farmers use more than they need because they are afraid that during a drought their entitlement may be cut to less than they need to make a profit. They may also fear increased costs for water as a free market for the commodity develops. Cheap water was the key condition for settlement of the West; because of that, western water law and custom have been shaped by the desire to protect farmers from market forces.

Farmers likewise are leery of the complexity of the market, which contrasts sharply with the simplicity of having a federal agency build and run a project and guarantee the supply of cheap water.

Nor do farmers want to sacrifice their rural independence to big city lawyers and bureaucrats. Says Milenski, "Water is supposed to be a property right. By God, I can't see why you've got to go into court three hundred sixty-five days a year to protect it."

As a result, "these guys don't like the idea of transfers," says California Assemblyman Phillip Isenberg, who has championed water markets in the legislature. "They're not used to it. It is a radically different way of thinking. It strikes at fundamental and deeply held attitudes."

But the growth of urban water demand and the decline of agriculture's economic weight are changing both attitude and law. With continuing population growth, says Colorado water broker William McLemore, "it's just a matter of where people want to live. When all the supplies have been adjudicated and there aren't any more available, that is going to necessitate transfers."

Concludes David Kennedy, director of the California Department of Water Resources, "Increasingly, water marketing is being recognized as one of the elements of water management that are going to solve our water needs."

It is unlikely that the developing water market will be entirely free. "To subject water to the forces of a free market is simplistic," says Jerri Gilbert of Oakland's East Bay Municipal Utility District. "The other values—the instream uses, the social values—need to be sorted out in our political system." A host of questions need to be addressed as more and more water changes hands: Who—the farmer or the irrigation district—has the right to sell the water? Must

ditch and canal companies make their facilities available to transport third-party water? What protections shall be required for local communities and the environment?

As answers to these questions are hammered out, there will be increasing participation in water issues Isenberg expects that to protect rural interests, the California Legislature may require environmental impact reports on transfers. "Conceptually," he says, "that allows everybody to get in."

William McLemore cites a Colorado law that requires maintenance of vegetation on a piece of land when its water is sold and concludes, "Each time a transfer runs through the courts, they may carve off portions of those rights for the public and the environment."

Walraven Ketellapper observes that in Colorado, where anybody may object to a transfer before the Colorado Water Court, "there are more people involved. There are more laws. There are more water attorneys. In one, small, two-hundred-acre-foot transfer before the Colorado Water Court, there were twenty objectors. A few years ago there might have been only two."

The increased participation may have great benefits for the environment. Says California's David Kennedy, "Increasingly, the Department of Water Resources recognizes that environmental resources have not been dealt a fair hand. Both fisheries and waterfowl have not had adequate water reserved to them." Water marketing is beginning to restore some of that water. Isenberg recently persuaded the California Legislature to offer $60 million to the City of Los Angeles to buy water from San Joaquin Valley farmers to replace water it formerly took from Mono Lake. Private groups in California are trying to buy water rights to convey to the state and federal refuges that host nearly fifty percent of the Pacific Flyway's waterfowl in winter. Those refuges hold rights to almost none of the water they need to survive.

In Colorado the Chevron Corporation donated $7.2 million worth of water rights on the Black Canyon of the Gunnison to the Nature Conservancy, which passed the rights on to the State of Colorado. The state can legally reserve the water as instream flow for the benefit of the trout fishery and three endangered species—the Colorado squawfish, the razorback sucker, and the humpback chub.

In Idaho, when low water levels froze over a wintering area for trum-

peter swans, the Nature Conservancy rented irrigation district water to run through the Upper Snake River, opening up essential water so the swans could feed. Congress recently appropriated more than $1 million to be spent acquiring water rights for the Stillwater Wildlife Management Area in Nevada.

Isenberg suggests that California conservationists write Secretary of the Interior Manuel Lujan "a letter offering to pay five dollars more an acre-foot than any farmer offers" for BuRec project water, and then use that water to benefit wildlife.

So, if profiting from water poses the risk that water will become a commodity, to be mined like timber and petroleum, it also offers a golden opportunity. Says water-policy consultant Steve Shupe: "Water is related to quality-of-life values that are not measured in economic terms. Having water nourishing wetlands or waterfalls sustains us in the West on some level other than dollars in the pocket. As water is treated more and more as a commodity, I think those values will grow."

But none of these changes is likely to come about quickly or without conflict. A measure of that growing conflict is the resignation, late in 1989, of Maurice Strong from AWDI's board of directors. Strong says control of the board had passed to a small group of investors who did not share his concerns for the welfare of the San Luis Valley and its environment, and that he had lost his influence over the company's decisions. He says he has faith in the company's management but "strong differences" with principal shareholders.

Strong himself owns a home on the edge of AWDI's Baca Ranch. Now that he no longer has a voice inside the company, he may find himself with the valley's farmers, arguing from the outside. "If I have to argue," he says, "I will argue."

And the turnabout makes him all the more eager to change western water policy. "With Colorado's use-it-or-lose-it law, there's no alternative but staking your claim before someone else stakes a claim," he says. "I think we've got to change our minds on water. You've just got to relate water to the larger issue of a conserver economy. Both rural and urban areas are guilty of using water extravagantly. If they use it wisely, they won't need these projects for years. If water could be saved for many, many years without development, I'd be happy."

OIL & GAS JOURNAL May 21 '90 p-30

WATCHING WASHINGTON

with Patrick Crow

Subsea pipeline worries

Rep. Billy Tauzin's proposal that subsea pipelines be inspected annually has the oil industry concerned.

Tauzin (D-La.), chairman of the House coast guard and navigation subcommittee, is considering filing a bill to require operators to inspect oil and gas lines in shallow, navigable waters—and rebury them if necessary.

The Transportation Department's office of pipeline safety (OPS) and the U.S. Army Corps of Engineers regulate nearshore lines, most of which are in the Gulf of Mexico. Both require that new lines be buried in the seabed, but neither requires industry to ensure lines remain buried.

Fatal accident's role

Tauzin's concern is prompted by an accident last October, in which the fishing boat Northumberland hit a Natural Gas Pipeline Co. of America pipeline off Port Arthur, Tex., killing 11 crew members (OGJ, Mar. 12, p. 29).

The line was buried when laid in 1973, but erosion had uncovered it. And the boat was operating at zero draft.

Current regulations require lines in less than 12 ft of water to be covered by 3 ft of soil or 18 in. of consolidated rock. Tauzin would change that to 4 ft of soil or 2 ft of rock in waters of 22 ft or less.

George Tenley Jr., OPS director, testified last week that by fall his office hopes to find ways to improve safety of offshore lines and fishing boats.

Also, OPS will issue a rule this summer requiring gas line operators to maintain current maps—noting dimensions, repairs, inspections, and tests.

Tenley said DOT already has all the legal powers Tauzin's bill would bestow—except perhaps to require existing lines to be reburied.

Jerry Verkler, senior vice-president of Interstate Natural Gas Association of America, said industry has not found an effective method to measure the overburden covering pipe or detect conditions contributing to exposure.

He explained that divers can see little in murky Gulf of Mexico waters, and side scanning sonar is not yet practical or accurate.

"Frankly, with the many thousands of miles of pipelines located underwater, both inland and offshore, and the limitations of weather, the inspections required by the proposed bill cannot possibly be accomplished each year."

Ingaa argued any change in burial depth requirements should be prospective, unless an existing line is in an unsafe condition or a hazard to navigation.

Verkler said fishing boats often operate in waters equal to or less than a vessel's draft without consulting navigation charts giving the presence of seabed pipelines.

"Mud or silt cover over a properly installed pipeline will not prevent a large, steel hulled fishing vessel from damaging the pipeline," he said.

Slim threat—now

At present, the Tauzin bill is a slim threat. It hasn't been filed yet; other committees share jurisdiction; little time remains for House passage this session; and there's no parallel effort in the Senate.

But if passed, it would be a tremendous blow to the pipeline industry. And in making laws—like in the flower business—it's the thought that counts.

ARCO market tactics obtain top court OK

The U.S. Supreme Court has upheld ARCO's competitive gasoline marketing tactics in California.

Independent retailer USA Petroleum Co. (Usapco) sued ARCO, alleging it violated antitrust statutes in 1982 by setting dealer price ceilings that matched Usapco's prices.

Usapco lost in federal district court, but the Ninth Circuit Court of Appeals overturned the judgment, holding that injuries from nonpredatory maximum price fixing agreements could be the basis of a lawsuit under antitrust laws. The Supreme Court reversed that in a 7-2 opinion. Justice William Brennan, writing for the majority, said although Usapco may have suffered an injury, it was not an antitrust injury under the law because it was not attributable to an anticompetitive act. The opinion said USA failed to show that ARCO's prices were anything more than competitive and noted antitrust laws were designed to promote competition, not protect competitors.

"When prices are not predatory, any losses flowing from them cannot be said to stem from an anticompetitive aspect of the defendant's conduct," Brennan wrote. "Low prices benefit consumers regardless of how those prices are set, and so long as they are above predatory levels, they do not threaten competition."

Justices John Paul Stevens and Byron White dissented, arguing the ARCO tactic might lower short term prices, but would lessen long term competition.

The court has yet to issue an opinion in another petroleum products pricing case. In Texaco vs. Hasbrouck, the question is whether Texaco violated antitrust laws by granting wholesalers a discount that is passed on to retailers, undercutting the price Texaco offers directly to its own retailers. •

OIL + GAS JOURNAL MAY 1 1989
p 68-

OFFSHORE REPORT

Technology for larger deepwater pipelines lags behind industry's development plans

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Technology development for deepwater construction of medium and large-diameter pipelines has stalled in recent years as the depressed state of the offshore-construction industry brought curtailment of research and development efforts in this area.

Low utilization rates of offshore-construction equipment has further discouraged investments in the building of new specialized deepwater-pipelay vessels.

Modifications to present deepwater pipeline design and installation approaches can meet the challenges of deepwater installations for the late 1990s.

What's done; what's coming. Practical experience has been gained on several projects in the Mediterranean, U.S. Gulf of Mexico, and offshore Brazil.

In 1979-1981, Saipem's large semisubmersible laybarge Castoro Sei installed several 20-in. pipelines across the Mediterranean in a record depth of 2,000 ft.[1]

The recent installation by bottom tow of flow line and pipeline bundles down to 2,300 ft in Placid's Green Canyon 31 field has shown the potential as well as some of the limitations of that method.[2]

Offshore Brazil oil field developments have also moved to water depths of as much as 2,000 ft with the extensive use of flexible pipe.

And deepwater development projects calling for medium and large-diameter pipelines in water depths of 3,000 ft are currently being planned for the next 3-5 years. By the late 1990s, plans include projects in up to 6,000-ft water depths.

Scheduled 1989 installation of the 12-in. Shell Bullwinkle pipeline in 1,350 ft in Green Canyon will push the limits of conventional laybarge equipment.

Projects on the immediate horizon which will reach 3,000 ft include development in the Gulf of Mexico's Viosca Knoll area and the Marlim and Albacora fields offshore Brazil.

External pressure. The primary factor determining deepwater pipeline and flow line design is the external hydrostatic pressure.

The pipe-wall thickness must be selected to provide adequate protection against collapse and buckling when the pipe is subjected to the combined load of external pressure and the bending and tensile loads introduced during installation.

The two main design criteria in use are buckle propagation and collapse. The propagation criterion requires that the wall thickness of a pipe be selected so that if a buckle occurs it does not propagate along the pipeline.

Various researchers have conducted experiments and developed theories and formulas to determine the relationship between the pipe diameter and wall thickness (D/t ratio) and the external pressure (or water depth) at which a buckle no longer propagates.

Fig. 1 gives a typical representation of this correlation.

The collapse criterion considers the combined loading of external pressure and tension and bending during laying, taking into account the effect of out-of-roundness.

Fig. 1

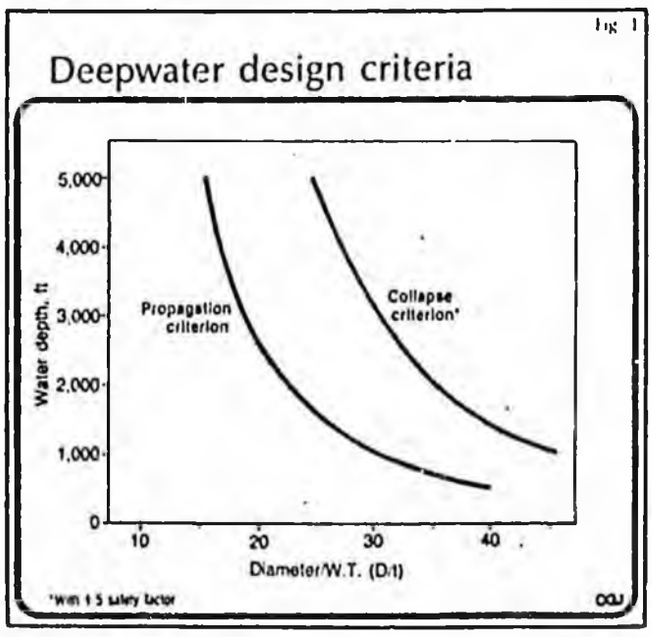
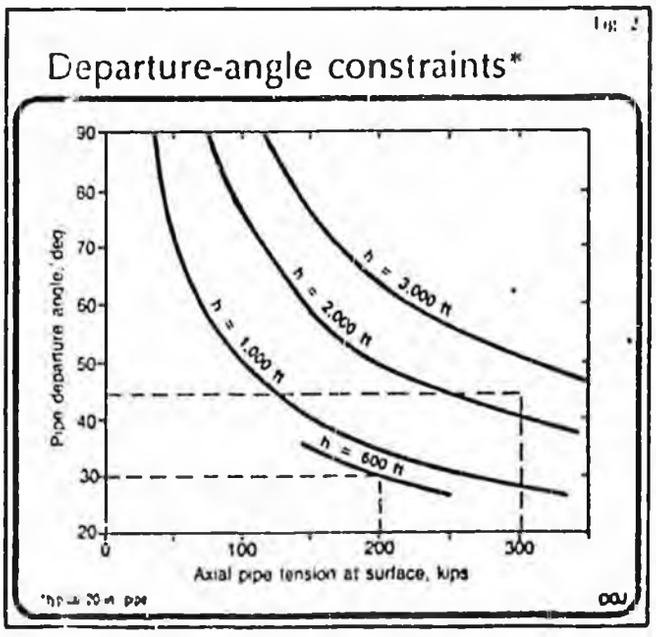


Fig. 2



Particularly for the low D/t range where collapse is no longer elastic, continued research is warranted better to understand the process and to obtain more empirical data from full-scale tests.

To the external pressure which in combination with the other factors would cause the pipe wall to collapse, a safety factor is usually applied to arrive at the design D/t. The D/t value is also shown in Fig. 1, based on a safety factor of 1.5.

It can be seen that the collapse criterion results in a lesser wall thickness than the propagation criterion and is therefore less conservative.

Which of the two criteria to select depends on how the risk of buckling, and hence of buckle propagation, is assessed and on cost considerations. Installation methods such as towing usually involve limited bending, so that the risk of buckling is lower than for a lay-barge method.

On the other hand, the use of a conservatively high wall thickness can increase the submerged weight of the pipe to the point of making the installation impossible.

Considering also the material cost, there is a rationale for using the propagation criterion for pipe-wall selection of smaller diameter pipelines where the cost impact is limited. For the larger diameters, the collapse criterion is appropriate in combination with buckle arrestors to limit the damage, should a buckle occur.

Present methods. The most common methods of pipeline installation use surface vessels to make up the pipe and lower it to the seafloor.

The pipe has an S-curve configuration in which the overbend curvature is controlled by a stinger which provides support through buoyancy or by structural means, while the curvature in the sagbend is determined by the submerged weight of the pipe and the tension force applied to it at the deck of the lay vessel.

In shallow-to-intermediate water depths, the pipe-tension requirement is determined by the allowable bending stress in the sagbend. In deep water, however, where the submerged pipe weight is often much less, it is desirable to keep the pipe from bending excessively over the end of the stinger that governs the tension.

The angle at which the pipe leaves the stinger, the departure angle, is a critical parameter since most vessels are limited in this regard by the stinger geometry. In deep water this means that the pipe tension can be reduced if the departure angle is increased.

This is graphically illustrated in Fig. 2 where the departure angle/tension relationship is shown for a 20-in. diameter pipe in a range of depths.

Table 1

Pipelay options for 3,000-ft Gulf of Mexico example*

• Third-generation laybarge from the North Sea:	
Mob./demob. (2 × 30 days @ $250,000/day)	$15.0 million
Laying (30 days @ $350,000/day)	10.5 million
Conversion/upgrading	4.0 million
Total installation	$29.5 million ($993,000/mile)
• Dynamic positioned lay vessel converted for J-laying:	
Mob./demob. (2 × 15 days @ $100,000/day)	$3.0 million
Laying (45 days @ $150,000/day)	6.8 million
Conversion/upgrading portion charged	10.0 million
Total installation	$19.8 million ($666,000/mile)
• Conventional laybarge combined with bottom tow:	
Mob./demob. barge (4 days @ $100,000/day)	$0.4 million
Laying up to 1,000 ft (30 days @ $130,000/day)	3.9 million
Barge modifications	2.0 million
Add'l materials for towing 10 miles	2.5 million
Pipe make-up and launch	2.1 million
Survey and tow-out	1.2 million
Intermediate tie-ins	2.4 million
Total installation	$14.5 million ($483,000/mile)
• Drillship converted for J-laying:	
Mob./demob. (4 days @ $100,000/day)	$0.3 million
Conversion cost charged to project	10.0 million
Laying (60 days @ $120,000/day)	7.2 million
Total installation	$17.5 million ($587,000/mile)

*Rates and costs are estimates for illustration purposes only
†Average of lay ($315,000/mile) and tow ($820,000/mile)

A conventional laybarge with 200 kips (200,000 psi) tension capacity and a maximum angle at the end of the stinger of 30° can lay the 20-in. pipe in up to 600 ft water depth.

Conversely, one of the large semisubmersible laybarges operating in the North Sea which can achieve a departure angle of 45° and has 300 kips of tension capacity, could theoretically lay this pipe in 2,500-ft depth.

By further extending the capacities of existing equipment, the operating depth can still be increased, provided that the vessel can efficiently operate its mooring system.

Guide modifications. The most effective enhancement of existing equipment in this regard would be to stingers or guides which would allow greater curvature and thereby result in greater departure angles without increasing tension capacity.

Controlling the pipe configuration in the overbend more rigidly and taking advantage of the nonlinearity of the stress-strain relationship of high strength steel can allow a much greater curvature than is based on the traditional "80% of yield." For a 20-in. pipe, the maximum radius of curvature would traditionally be 320 ft, to which an allowance must be applied to account for the rotation at stinger hinges and articulations.

On the other hand, by use of a fully controlled rigid-curvature guide and an allowance of 0.2% residual strain as permitted by some codes,[1] the bending radius could be reduced to 230 ft. For an overbend length of 300 ft, the maximum departure angle thereby increases from 33° to 75°.

Based on the curves in Fig. 2 this would increase the depth capability from 600 ft to well in excess of 3,000 ft for use of 200,000 lb of pipe tension. Using these high bending strains will result in some residual curvature in the pipe unless a straightener is used at the end of the overbend guide.

Bending the pipe in the plastic range is commonly done in the reel method. From this experience we know that residual stresses and strains can be acceptable provided one takes this into account in design and material selection.

Mooring limitations. If the capability of conventional equipment can thus be extended, the mooring system will become the limiting factor. The combination of deep water and high pipe tension will make positioning and advancing of a laybarge moored with 8-14 anchors increasingly difficult and time consuming. This anchor-handling problem can be avoided by use of dynamic positioning (DP). This would require high forward thrust to counteract the pipe tension, however, resulting in high fuel consumption.

This is another reason to increase overbend curvature and reduce tension requirements for a better bal-

Fig. 4

Pipe-towing alternatives

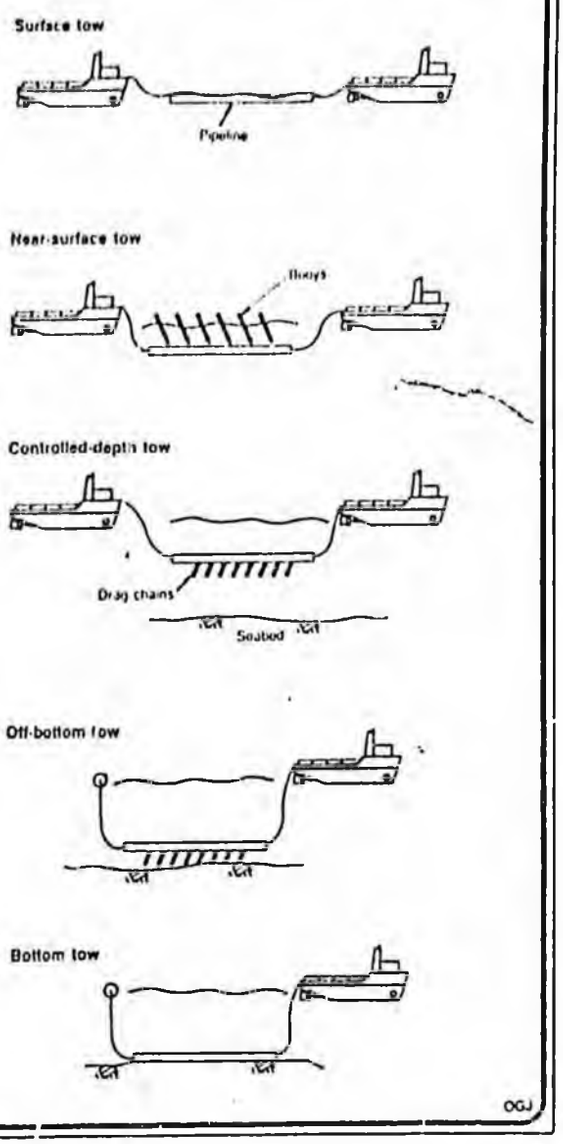


Fig. 1

J-curve lay system*

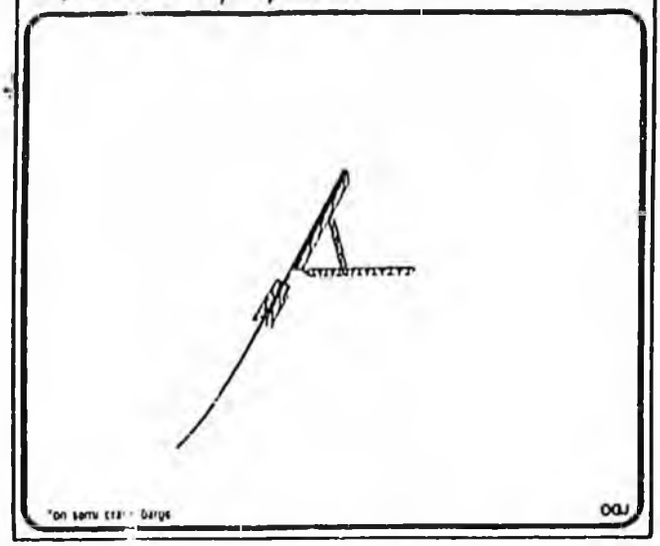
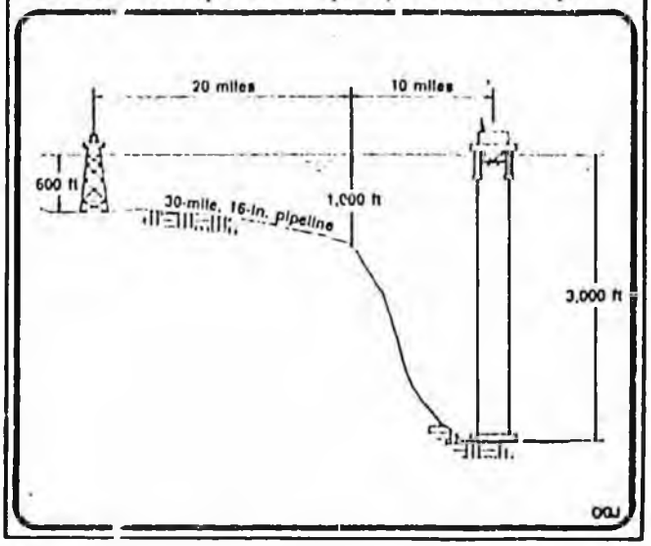


Fig. 5

GOM deepwater project: example



anced deepwater laying system.

For the Gulf of Mexico, deeper water capability could also be obtained by use of one of the large North Sea vessels. The cost of mobilizing and operating these vessels will be very high by Gulf of Mexico standards, a situation not likely to improve in view of the increase in demand created by several very large projects scheduled in the North Sea for the early 1990s.

Consequently, there is an incentive for development of practical, lower-cost alternatives for the Gulf of Mexico and offshore Brazil.

Additional methods. Once the possibilities of the S-curve laybarge method have been exhausted, three alternatives exist, namely the reel method, the J-curve method, and towing techniques.

The reel method has been used successfully for installation of pipe from Exxon's Lena guyed tower in up to 1,150-ft depth. Particularly the vertical reel system can achieve greater departure angles than conventional S-curve equipment, without the use of a stinger, requiring less tension.

It is therefore better suited for dynamic positioning which enhances its deepwater capability. Only one such vessel currently exists, the Santa Fe Apache, which is limited in the pipe diameter it can reel to 16 in.

With the available tension of 200 kips, and the 60° maximum departure angle, it can theoretically install a 12.75-in. pipe in close to 3,000 ft depth in areas of low to moderate currents. These operating limits could be increased by providing for even greater departure angle and by strengthening the tensioning and DP system.

In the J-curve lay method, the pipe is installed from a surface vessel in a vertical or steeply inclined orientation.

Fig. 2 indicates that this pipe orientation results in minimal horizontal tension requirements, which reduces thrust requirements of a DP system. Therefore, this concept lends itself to pipeline installation in much greater depths than the S-curve method.

A drawback of the J-curve concept is that the near vertical pipe make-up allows only one pipe-joining station to be used, which adversely affects productivity.

For this reason, considerable research has been carried out into the development of high-speed joining systems, including advanced welding techniques for vertical pipe welding, forged connections, and threaded connectors. To improve the produc-

tion rate, the length of pipe joined at this single station can be increased by using multiple joints of pipe.

Conversion option. At present, no J-curve lay vessel exists. In view of the limited number of deepwater pipelines, their limited length, and the still existing oversupply of offshore installation equipment, the construction of a newly built J-curve lay vessel would not be commercially justified. Most concepts are therefore based on a conversion of existing equipment.

Consequently, designs have been developed to convert drilling semisubmersibles or ships, derrick barges, or S-curve lay vessels to operate in this mode.

Drilling vessels have many of the attributes required for J-curve laying, such as a high vertical lifting and tensioning capacity and a powerful DP system. However, since the vertical space in a drilling derrick is normally set up for 60-ft pipe lengths, the production rate will be low unless this length is increased or a high-speed welding system is commercially available.

In intermediate water depths, the pipe orientation at the surface can no longer be vertical because this would lead to excessive bending in the sag-bend. Therefore, an inclined ramp with adjustable angle would be required to enter into shallower water.

Adaptation of existing construction vessels such as laybarges and derrick barges would be another viable and potentially economic approach. A successful J-curve laying system would have to strike the right balance between cost of operation and productivity and be competitive not only in deep water, but also in water depths within the range of capabilities of the large laybarges.

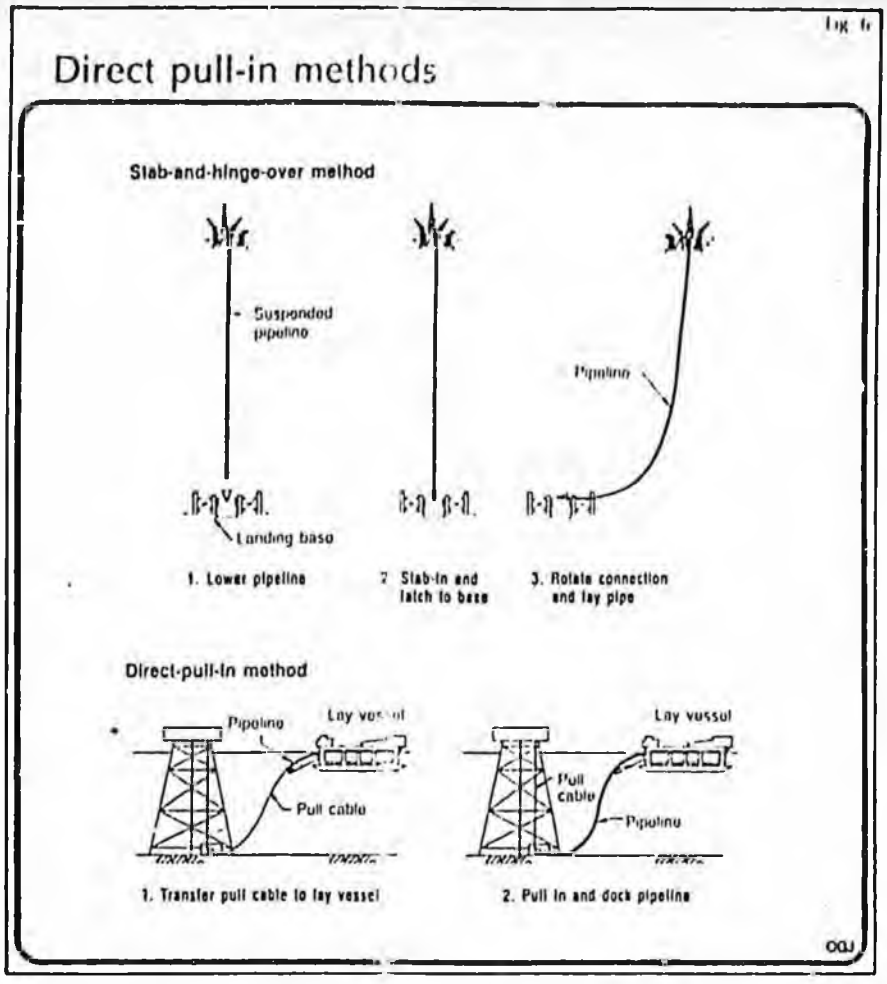
An optimal system would combine a large deck area for welding single pipe joints into long sections, a reasonably fast single-station joining system and a DP carrier vessel which is reasonably priced because of a low daily rate, a low mobilization cost, and/or low conversion cost.

Ideally, a J-curve laying system for the short deepwater pipelines in the Gulf of Mexico should be modular so that it can be installed on and operated from a vessel of opportunity which is already mobilized for a project.

An example of this is illustrated in Fig. 3 showing a conceptual J-curve laying system on a derrick barge. Deepwater developments are likely to require such heavy-lift vessels to install TLP (tension-leg platform) anchoring, templates, and riser bases, so that additional mobilization costs may be avoided.

For successful deepwater operation it is necessary that the carrier vessel be dynamically positioned. Except for drillships and a few heavy-lift vessels, offshore-construction vessels would have to be retrofitted with a DP system to meet this requirement.

Fig. 6



Towing. There are various methods which have successfully been used to tow long lengths of single pipe or pipe bundles to an offshore location.

These methods have in common that the pipe is welded up into long sections at an onshore location, in a controlled and rather low-cost environment. The sections are then joined at the shoreline while successively being pulled into the water and subsequently towed to the final location as one entire assembly.

This assembly may consist of a single line, dual gas and liquid lines, or a flow line bundle. Multiple lines can be strapped together or placed inside a casing pipe.

There are basically five towing attitudes as shown in Fig. 4, which all have their specific area of application.

For calm sea conditions, the surface-tow method has the advantage of simplicity, but in deepwater the pipe-lowering process can become quite intricate.

The most experience has been gained with the controlled-depth tow and the bottom tow for installation of single pipes or bundles.

The controlled-depth tow method has been applied primarily in the North Sea for cased bundles of up to 5 km in length in water depths of up to 500 ft. The bottom tow has seen applications worldwide, including recent installation in the Gulf of Mexico of pipeline bundles of more than 9 miles in depths of up to 2,000 ft.

The bottom tow has the advantage of inherent pipe stability if the tow must be interrupted, but requires detailed knowledge of the seabed along the tow route, often several hundred miles long. This calls for extensive and costly survey work.

The bottom tow will interfere with existing pipelines and subsea facilities unless special precautions are taken. Near-surface tow or controlled-depth tow are not hampered by seabed obstructions but require greater attention in ancillary equipment and rigging to control the pipe position and attitude at all times.

The critical element in all tow methods is maintaining a low submerged weight in order to maximize the towable pipe length or minimize the required towing horsepower. Achieving this low submerged weight while maintaining stability requires a tight control of pipe dimensions and coating density and thickness.

A pipe designed for installation by the traditional laybarge method will generally not lend itself to economical installation by towing due to the high cost of buoyancy in deep water required to offset the higher submerged weight or the cost of intermediate tie-ins necessitated by pipe length limitations.

Flow line bundles. For deepwater pipelines, towing methods are best suited for flow line bundles for which the buoyancy can be provided by a continuous external casing pipe, and multiple lines can be installed and connected simultaneously.

For installation of single pipelines, towing is less well suited, particularly in the case of gas lines. The design submerged weight of a gas pipeline is governed by the worst environmental conditions anticipated over its lifetime because the gas content adds little to the pipe weight.

Consequently, the pipe will be heavier than needed strictly based on the installation conditions, and the higher weight tends drastically to reduce the length of pipe that can be towed. For towing longer strings, a considerable amount of temporary buoyancy would have to be used.

For flow line bundles or multiple pipelines of up to 5 miles' length, therefore, towing is a viable alternative based on bottom tow, controlled depth tow, surface tow, or a combination of these. For single oil pipelines, bottom tow has application in water depth beyond laybarge capability, and for pipeline lengths which are insufficient to justify the development of special deepwater laying equipment. The most economical solution for a given project may be a combination of methods. At present there is no contractor offering pipeline installation by towing in the Gulf of Mexico or in Brazil. To be able to make use of the potential advantages of this method, such contracting capability would be desirable because not every oil or gas company will be prepared to undertake this type of a project under their direction.

Because equipment and technology are available, all that is required is the combination of the right construction and engineering resources and the development of several suitable pipe make-up sites.

Installation selection. Selection of the optimal techniques from the described alternatives depends on the circumstances of the project and the limitations of each method. In general terms, conventional laybarges can be upgraded without excessive costs to install pipe of 20 in. diameter in up to 1,000-ft depth, and lesser diameters in up to 1,500 ft.

Beyond these limits the reel barge can be used for the smaller diameters in excess of 2,000 ft depth. Diameters of 16 in. and larger, however, require that either a North Sea laybarge be mobilized, that an existing barge be outfitted with a high curvature guide and dynamic positioning, or that a J-curve vessel be developed through conversion of existing equipment.

The large semisubmersibles could be capable of installing a 20 in. pipe in up to 2,500 ft depth, and possibly more, but the vessel dayrate would be equivalent to North Sea levels, and the mobilization/demobilization costs would similarly be high. Furthermore, the deep water will most likely require modifications to the mooring system.

Conversion of an existing drilling or construction vessel for J-curve laying is then the remaining option. How cost effective this solution is depends on the dayrate of the vessel, the production rate it can achieve, the cost of conversion, and on what proportion development and conversion costs are charged to a given pipeline project.

Towing is an attractive alternative for the installation of flow line or pipeline bundles or a short deepwater section of single pipe to complement the capability of existing laying equipment. The cost aspects of these alternatives can be illustrated by the following example:

Assume a project in the Gulf of Mexico requiring a 16-in. oil pipeline between a platform in 600-ft water depth and a TLP in 3,000 ft depth, where the distance from the platform to the 1,000-ft depth contour is 20 miles, and from there to the TLP another 10 miles (Fig. 5).

Consider the options presented in the accompanying box.

The example clearly demonstrates how important mob/demob costs and the percentage allocation of conversion cost can be in evaluating options for a given project.

The example also illustrates that conversion of locally available equipment and the combination of different methods can be an economical alternative for deepwater projects.

Tie-ins, connections. At least as important as pipeline and flow line installation is their tie-in to deepwater production structures such as subsea wells, manifolds and platform risers, because this will require diverless techniques.

Tie-ins can be executed either as first or as second-end connections.

First-end connections can be made by direct pull in, by lateral deflection, stab and hinge over, or by use of steel or flexible spool pieces. Two of these methods are illustrated in Fig. 6. For second-end connections, the deflection and spool piece methods are best suited.

The typical diverless connection process involves three distinct steps.

First is rough alignment in which the pipe end is placed in the approximate orientation and position required. Second is structural engagement between the pipe and the subsea structure in which the pipe end is brought in the desired position within close tolerance and locked down. And last is the actual connection and sealing of the two pipe ends, usually by mechanical connector.

The direct pull-in method (Fig. 6) uses a cable to pull the pipe into a docked and locked position on the subsea structure as the installation vessel lays it down. The cable can be rigged to a surface vessel or a subsea pull-in winch landed on the structure.

Because only limited force is allowed on these structures, the direct pull-in is less compatible with the S-curve laying method and bottom tow, both of which involve large tensile forces in the pipe. It is well suited, however, for J-curve installations where horizontal forces are much lower.

The vertical stab and hinge-over first-end tie-in method (Fig. 6) consists of lowering the pipe vertically and stabbing the free end into a receiver on the seabed structure similar to guidelineless re-entry technology already in use with deepwater drilling. Once the pipe end is latched in place, the receiver is rotated to a horizontal position as the lay vessel moves away.

Because of the pipe orientation this method can only be used with the J-curve method of installation.

For a second-end spool piece tie-in in deep water, the traditionally diver-assisted steps have to be executed remotely. These steps include accurate measurement, spool-piece deployment, and connector alignment and setting.

To simplify the tie-in operation, an L-shaped spool piece is preferred because it allows the various degrees of freedom to be dealt with successively, rather than simultaneously. The axial movement required for make-up of the second connector can then be provided by the lateral movement of one of the pipe ends, obviating the need for swivels.

The lateral deflection technique can be used for first and second-end connections and involves placing the pipe end in a target window and deflecting the end laterally into a receiving structure. This method is widely practiced for connection of small diameter flow lines to subsea wells, and numerical as well as physical models have been developed to aid in design, and to

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simulate the deflection process.

For larger pipe or flow line bundles the pipe is usually buoyed off bottom with buoys and drag chains to lower lateral resistance and better control the deflected configuration. Accurate placement of the pipe end in a predetermined target area is required to keep pull forces and final alignment accuracy within accepted limits.

Subsea structure. Critical to the whole deflection tie-in concept is the proper design of the pull-in and alignment system as an integral part of the subsea structure (template, manifold, or wellhead).

Frequently these facilities are designed and even installed long before pipeline or flow line details have been determined. This time gap can lead to high costs and less than desirable design solutions for the pipeline connection when incompatibilities must be corrected in a later stage.

On the Placid Green Canyon 29 project, the pipe-end sleds were large structures to allow connection to tie-in points high on the central template and weighed as much 165 tons.[5] Smaller and lighter end sleds would have simplified the towing process considerably.

The optimal pipe-end configuration is a narrow, streamlined, neutrally buoyant, axially symmetric pullhead.

To enhance pipeline design and installation simplicity, the following guidelines are recommended for the tie-in method selection and system-hardware design:

- Deflection procedures should use a single cable pull.
- Pull loads should be kept at less than 20,000 lb.
- Receiving structure should accept about ±5° of misalignment.
- Docking and engagement procedures should be reversible.
- The tie-in point should be close to the seabed.
- A passive alignment system is preferred if space on the subsea structure permits.
- Pipe end should be locked into fixed position, and final connection should be achieved by stroking inboard piping only.

The distinction between passive and active alignment systems lies in the manner in which the final adjustment in position and orientation is achieved.

Active systems rely on mechanical devices, usually hydraulically operated, to move and rotate the pipe end. For medium to large diameter pipes, this requires considerable force and consequently a strong structure.

The active-alignment concept is part of most integrated connection systems which have been developed by the major suppliers of wellhead equipment and involve components and tools which can be lowered onto the subsea structure.

Typically, a pull-in tool is used to pull-in and align the pipe, while a connection tool is used to remove the pipe-end cap, stroke both ends together, and actuate the connector. Since these systems are developed for flow line tie-ins, their load and moment capability thus far are limited, and the systems are currently unsuited for large-diameter pipe.

A passive alignment system relies on structural guides and restraints to align the pipe end by successively constraining the various degrees of freedom as the pipe end is pulled-in.

Although this concept requires more space on the tie-in facility, it is attractive in its simplicity because only one single cable pull can accomplish the entire precise alignment. Since the degrees of freedom are restrained successively, there is little risk of the pipe binding or becoming stuck, a problem which has been experienced in the past.

To facilitate the remote tie-in of pipelines to subsea structures in deep water, therefore, it is important to avoid unnecessary complications, and use a design which incorporates the requirements of the pipeline engineers at the earliest possible stage in the project. Failure to do so will lead to more complicated designs, higher costs, and unnecessary risks.

References

1. Bianchi, S., Cao, S., and Oliveri, V., "New solutions and improvements to pipelaying developed during construction of very deep water sealines within Transmediterranean project," OTC 4709, Houston, May 1984.
2. Clarke, P.L., "Green Canyon 29 Development," OSMC 1988, Houston, February 1988.
3. Rules for Submarine Pipeline Systems, Det norske Veritas, 1981.
4. Timmermans, W.J., "Deep water pipeline design and installation," OGJ, Dec. 17, 1984, p. 70, and Dec. 24, 1984, p.
5. Pollard, Bob, Laborn, Lacy, Frosty, Ray, "How Placid recovered the GC 29 pipeline bundle," Ocean Industry, November 1988, pp. 21-25.

Fast drilling

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Total Oil Marine plc
Aberdeen

A high level of performance was attained during the bulk of the development drilling program for the Alwyn North field in the U.K. sector of the North Sea during 1987 and 1988.

In fact, an average drilling rate of 200 m/day was exceeded during the drilling of the twenty-second well. The Alwyn program, which is still continuing. A combination of teamwork, engineering, and a willingness to innovate and use concepts from research and development led to these good, by North Sea standards, results.

Some specific elements that played a major role in this performance were thorough project preparation, performance incentive contracts, bottom hole assembly (BHA) software, the variable bent sub, and rock bits with extended nozzles and cross flow patterns.

Field drilling. The development drilling on Alwyn North field has been carried out since early 1987 by Total Oil Marine plc, operator on behalf of an association of Total Oil Marine (33.3%) and Elf U.K. (66.6%).

Alwyn North field is in the East Shetland basin (Fig. 1). The drilling facilities consist of a 40-slot, double-derrick drilling platform with accommodations (OGJ, April 27, p. 33, 1987). It is attached to a separate production platform by a bridge.

The conductor pipes were batch-set in December 1986, followed by the spudding of the first development well at the beginning of 1987.

The two rigs were used in simultaneous drilling operations for the first 18 months to drill a sufficient number of wells and ensure an optimum start-up production rate from the field. Only one rig is currently being used.

Drilling program. Two separate res-

aged. Department officials deny that there are any systematic problems.

The Buildings Dept. says that each year it makes some 500,000 inspections of sites with permits and scores of random block-by-block inspections to find sites without them. ■

By Carolyn M. Brown

UNIONS

Unions change policy on prehire drug tests

With less-than-unanimous support from member unions, the AFL-CIO Building and Construction Trades Dept. has changed its policy on drug and alcohol testing to allow prehire testing when required by owners or the government.

The change was adopted at a recent meeting of the department's governing board. Until now, the unions had condoned testing only when there is probable cause. The unions continue to insist that strict procedural requirements be observed, such as giving job applicants the right to hear confidential results from a medical official and to offer explanations. Applicants also can have samples retested at a lab of their choice, at their own expense.

Some union officials are highly critical of the change, claiming that it was pushed by local union officials who felt it was needed in order to get work. "It was a practice that certainly needed to be addressed," says one official. "On certain projects, it's going to be done or we're not going to get on the job."

John B. McCabe, who runs the substance abuse program of the sheet metal workers' union, argues that the science of testing is not accurate enough to support such a policy. "You're not giving a young person a chance before he starts to work," he says. McCabe also worries that jobs will be reclassified in order to test current employees. McCabe and others who accuse the governing board of "giving in to management" prefer the old probable-cause policy.

Building trades Secretary-Treasurer Joseph F. Maloney says that the department's lifting of the restriction on prehire testing was necessary to reduce local conflicts that arose when some area officials agreed to testing. With the policy change, says Maloney, "We're almost silent on the issue now." Department officials also believe the new policy will help reduce the number of grievances. ■

PRIVATIZATION

EPA eyeing privatization for clean water projects

The Environmental Protection Agency staged the first in a series of brainstorming sessions last week designed to find ways to win acceptance for the financing of public projects with private money. According to the 125 select participants, the key to the success of privatization is an education program to change attitudes in both the public and private sectors.

Seader: Responsibilities must be clarified.

Thomas: Conference is just the beginning.

"Overall, there is a need for the concept of public-private partnership," said Roger D. Feldman, managing partner of the project finance and development group of the Washington law firm of Nixon, Hargrave, Devans & Doyle and vice chairman of the Privatization Council. "In effect, the concept of a publicly chartered [private] venture must cease to be regarded as an oxymoron or a threat to public policy."

Building a network. Billed as the first National Leadership Conference on Building Public-Private Partnerships, the meeting was an effort to build a network of people and institutions in the environmental financing field and to establish an agenda. EPA's interest is in funding projects in the areas of drinking water supply, wastewater treatment and solid waste disposal, all of which are suffering from reduced federal funding.

"Whatever the challenges may be, we've got to commit to a far stronger link between private industry and the government," said EPA Administrator Lee M. Thomas. The agency hopes that the smattering of elected public officials, lawyers and bankers that attended the conference will blaze the privatization trail.

In its efforts to facilitate privatization over the next year, EPA plans to document cases of both successful and unsuccessful partnerships, identify private financing that states and communities can use and show the impediments and incentives to these arrangements, said Charles L. Grizzle, assistant EPA administrator for administration and resources management. He says the agency also will share information with communities on how to arrange public-private partnerships.

Other EPA officials noted that the agency plans to publish case studies, option papers laying out legislative and regulatory strategies, and self-help guides, including a videotape. Some may be ready by next month.

Feldman said there are at least six innovative approaches to facilitating public-private partnerships. They include:

- Using systemwide financing that is backed by user charges.

- Using tax assessments and impact fees.
- Leveraging revenue streams through revolving funds.
- Reducing financing costs through tax-exempt debt, investment tax credits and financing techniques such as lease-purchase deals.
- Minimizing project risk and increasing private sector participation through equity, risk management and insurance innovations.
- Performing contract management to stimulate innovative private packaging of tasks performed and risks assumed.

"There have been suggestions that the coming Congress may see proposals for reintroduction of [tax] credits," said Feldman. "While infrastructure development cannot await credit restoration, its potential utility to private developers—and potential to tap their capital—should not be underestimated." According to Feldman, tax credits in the environmental field represent a "justifiable" subsidy.

David Seader, vice president of Bankers Trust America Banking Corp., New York City, noted that there has to be a payoff for private participation. "The private sector wants profit," he explained. "It [also] has to be totally clear who takes the risk, what party pays, who is taking responsibility." Seader suggested that EPA take the lead by developing a "model services agreement." Added Richard Dewling, chairman of of M&T Technologies Inc., Somerville, N.J., "It is going to cost more to clean up wastewater and solid waste."

By Pete Hoffmann in Washington

NUCLEAR POWER

Soviets get German reactor

The Soviet Union signed a general agreement last week with a West German combine for cooperation in planning and building small high-temperature nuclear power units. It would be the first sale of such units, and the first time the USSR has ever acquired foreign reactors.

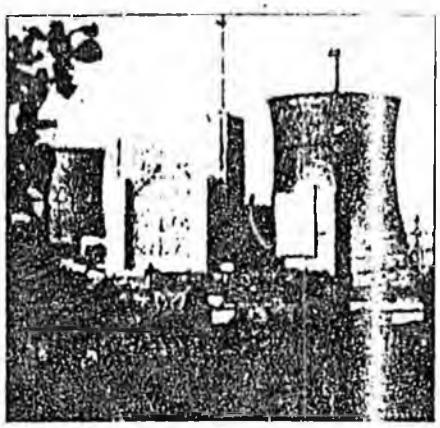
The pact was reached between the Soviet State Committee for Utilization of Atomic Energy and a joint venture of Asea Brown Boveri AG (ABB) with Kraftwerk Union AG, the nuclear plant division of Siemens AG.

The first phase calls for building a 200-Mw unit with a high-temperature reactor (HTR) at Dimitrovgrad, 680 miles east of Moscow, by 1996. It would cost more than $560 million. Planning and licensing arrangements will start this year, aiming for a construction start three years from now. The German consortium would receive about 40% of the project's cost.

An official of the combine says project approval will be sought from the Coordinating Committee for Multilateral Export Controls, a 16-nation group of Western countries and Japan that reviews delivery of sensitive technology to the Eastern Bloc. But committee approval will not be sought until licensing, planning and construction contracts are worked out.

The general agreement foresees joint construction of more HTR units to produce electric power as well as process steam and heat in the USSR and other countries following completion of the Dimitrovgrad reactor.

ABB was formed by a merger last year of the Swiss firm Brown Boveri & Cie and Sweden's Asea. Its German subsidiary in Mannheim signed the agreement with the Soviets.



Prototype unit went on-line three years ago

The large Mannheim office led a consortium that built the first prototype commercial HTR unit, a 300-Mw installation at Hamm-Uentrop. That reactor went critical in 1983 and started delivering power to the German grid in 1985. But it has been taken offline frequently for repair and testing. A new version would be supplied to the Soviets.

High-temperature, gas-cooled reactors are considered far safer than conventional ones. The small modular units use fuel spheres coated with graphite, which prevents fissionable material from escaping. Inert helium, which cannot burn or explode, percolates through the bed of spheres, absorbing heat. If an accident causes the core to overheat, the nuclear reaction shuts down. A demonstration pebble-bed reactor is to be built at the Idaho National Engineering Laboratory (ENR 4/9/87 p. 28).

HAZARDOUS WASTE

DOE may close weapon sites

Mounting concern over safety and environmental hazards of U.S. defense-related nuclear operations is forcing the Dept. of Energy to consider permanently closing some reactor sites. A DOE spokesman acknowledges that closure is an option but does not concede that it is being recommended.

DOE is expected to submit a report to Congress in mid-December about plans to continue weapons production through 2010. A draft of the report is now circulating within the department and reportedly calls for closing plants at Fernald, Ohio, and Rocky Flats, Colo., near Denver. The governors of both states last week called for permanent closure of the plants.

Underscoring the need for action, the General Accounting Office, the investigative arm of Congress, released a report last week claiming that DOE had understated the reasons for closing Rocky Flats. The report said DOE raised various safety and health concerns "over the past two years."

"Of particular concern have been inadequate management attention to the plant's health and safety programs, deficiencies in the plant's radiological protection program and the need for enhancing fire protection," it said. DOE did not dispute the report but said the exposure to a small dose of plutonium radiation by three people, including a DOE inspector, was a "catalyst" for closing the facility.

The GAO report found environmen-

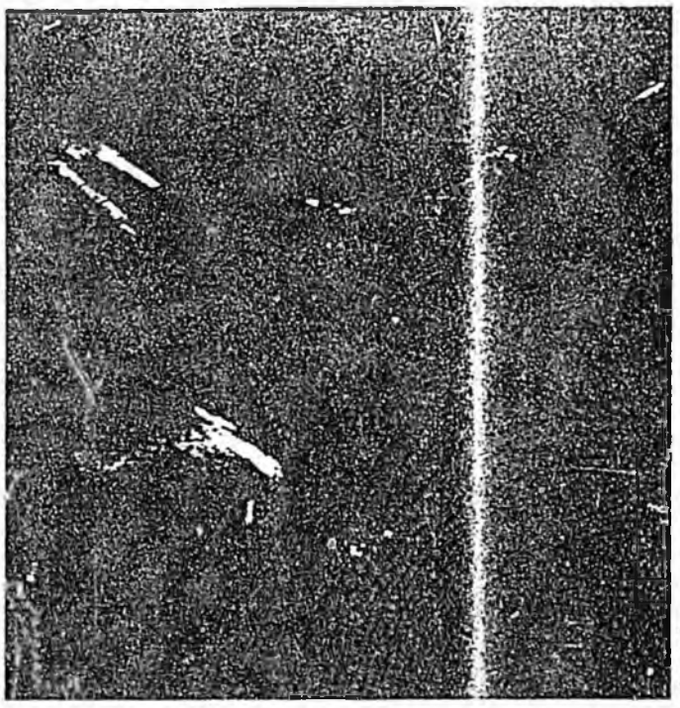
Climates For Change: Legacy of the Drought

Modern divining rods such as conservation, resource planning and wastewater reclamation are being used by American water officials to prepare for the future.

By Burt Nydes

Last year, America was hammered by the hottest, driest, most cantankerous weather in more than 50 years. According to the Climate Office of the Oceanic and Atmospheric Administration (NOAA), portions of 35 states experienced extreme drought conditions in 1988.

Especially thirsty regions included the Southwest, Northern Plains and Northern Rockies, the Northeast, Midwest, Southeast, and Southern Plains. The last drought that was substantially worse happened in 1934, which contributed to the Dust Bowl era.



AP/WIDE WORLD

Richard Heim, NOAA meteorologist in Asheville, N.C., provided several sizzling statistics about the drought of 1988-89. Precipitation in April, May and June of 1988 was the lowest ever recorded for the nation, and 1988 was the fifth driest year in 94 years, with an average annual precipitation of just 24.88 inches.

June, July and August 1988 ranked as the third hottest summer in 94 years, with an average national temperature of 73.4 F. Last year, from January to December, was the 16th warmest in 94 years, with an average national temperature of 53.1 F.

The winter of 1988-89 was the 14th driest in 94 years, and was the fifth consecutive winter in which rain and snow across the United States were below historical averages.

"The dryness of the winter of 1988-89 has inhibited recovery from the severe drought of 1988," Heim says. "At 1988's summer peak, the drought covered 40 percent of the contiguous United States. Approximately one-third of the country remained in a severe long-term drought as of March 1989. Although a few areas of the country actually had above average precipitation during this past winter, most regions had below normal or even record low precipitation."

Long-range forecasts from the National Weather Service indicate that hot and dry weather probably will affect many parts of the country into the summer of 1989.

The impact of last year's prolonged drought has been enormous. It ruined crops, devastated farmers, contributed to increased retail food prices, resulted in more forest fires, hindered navigability and restricted traffic on the Mississippi River, curtailed some hydroelectric plant operations, adversely affected coastal wetlands and wildlife, and shrunk essential water supplies. Reservoirs are down 20 to 30 percent for American cities and counties.

Appearing on NBC's *Today Show* in March, Mayor Thomas Whelan of Albany, N.Y., stood inside his city's main

reservoir, and said, "Ordinarily, at this time of year, where I'm standing I'd be underwater. Our reservoir is now down about 4 billion gallons. We're at the lowest point we've experienced in the past 26 years."

Jay Lehr, executive director of the National Well Water Association (NWWA), sees the extended drought as a serious national problem, but not as an unmanageable crisis.

"The United States perceives itself to be facing an impending water crisis as the result of increasing drought cycles, the potential for a temperature increase resulting from the widely reported greenhouse effect, naturally inadequate surface and groundwater supplies in some regions and localities, and resources lost as the result of pollution," he says.

"Doomsday viewpoints are based on extremely rough conceptual models of how the world's weather patterns are changing. The reports evolve from historical weather data using barely 100 years of records to predict climate changes in a world that is millions of years old."

Lehr says that major changes in weather or water supplies should not be anticipated for another 50 years.

"We can expect increasing demands on the available supplies, but we are well equipped to continue balancing supply and demand," he says. "We will not need new-fangled technology or the discovery of untapped reservoirs. We simply need to put in place existing concepts of water conservation, water resource planning, and reuse."

From an educational standpoint, Lehr says the most recent drought is not all bad. "Drought, increased heat and reduced water supplies are now part of our short-term history. Thus, for the first time in recent years there is hope that widespread public interest in conservation won't dissolve with the next burst of heavy rainfall."

American farmers need to be edu-

Arid Arizona City Conserves, Manages Water

Water management is serious business for an area that receives 11 inches of rain a year and has two months of temperatures over 100 degrees.

In the arid southern Arizona environment around Tucson, water for household use and irrigation is a treasured commodity that has spawned several decades of legislative and legal battles. Tucson is one of the largest cities in the world that is dependent totally on wells for its water needs. The Tucson Water Co. currently uses 198 wells to provide water to 553,152 customers in a 285-square-mile service area.

The way that the city has cut its Gordian knot of water crises has set an example for those looking to protect their own supplies. Tucson's action includes the use of mandatory management legislation and voluntary conservation measures, farmland reclamation and the installation of high-quality monitoring and control devices.

The main challenge facing Tucsonans is finding a way to stop the steady depletion of southern Arizona groundwater reserves. The utility estimates that water is being used at about twice the rate it is being replaced.

Reclaimed wastewater is used to irrigate Tucson golf courses, parks and school grounds.

This negative flow is seen as a critical problem even though most of the city's wells reach more than 400 feet into the water table. Since Tucson Water expects to be serving more than 900,000 customers within 10 years, the utility has undertaken a number of new water conservation and supply efforts.

"One of the most important methods of conservation is to have accurate metering throughout the system," says William Wright, administrator of Tucson Water's division of water resources. "Accurate metering provides the accountability needed to tell how much water other conservation efforts are saving."

The utility uses MW500 main line propeller-type flowmeters manufactured by the McCrometer Division of Ketema Inc., Hemet, Calif. About 180 are used to measure the amount of water coming from wells and 70 are used in booster pump applications.

With its flow measurement apparatus in place, Tucson Water is tackling one of the most controversial measures of the state's 1980 Groundwater Management Act. It requires that, by the year 2025, each of Arizona's four active management areas balance the amount of water they are taking from the ground with the amount that is recharged annually.

"We call it our bank account," Wright says. "We recharge water and then we extract it. For every 12-month period, we try to have a balance in the account where we did not extract more than was put in."

Currently, recharged water comes in the form of rainfall and runoff from the melting of distant snow, but the utility is studying the use of treated water from the local Pima County Wastewater Plant. This water, which meets federal standards for plant discharge, could receive further treatment and then be injected into unused wells to replenish the water table.

Reclaimed wastewater already is being used by the utility to irrigate several golf courses, parks and school grounds in the city. Tucson Water diverts about 8 million gallons a day of the plant discharge and, after filtering and disinfection, sends it to customers through a separate water system.

The Arizona Department of Natural Resources also has taken over management of the Central Arizona Project. This massive public works undertaking is a water-delivery system that will bring about 219 billion gallons of water a year from the Colorado River to the Tucson area by 1992.

But the water management program that has received the most attention in Tucson is a fully voluntary conservation program called "Beat the Peak."

Residents have been heeding the directive of the program's animated mascot, "Pete the Beak," to refrain from watering between 4 and 8 p.m., and only every other day. Average water use per person in Tucson dropped from 205 gallons a day to 161 gallons since the program began.

With all the natural water supply problems the city has to deal with, there is a brighter side to the picture. For the past several years, Tucson has claimed the semiofficial distinction of having the nation's best-tasting drinking water.

"We have won a number of water-tasting contests and we think it's because our wells are so old and so deep that the water is very pure," Wright says. "It seems fitting that, in a place where there is barely enough water to go around, for some reason it should taste better than anywhere else." □

cated about low-cost methods, such as drip or surge irrigation, that can improve irrigation efficiency and reduce the great wasting of water that results from common center pivot sprinklers, Lehr says. New strains of grains and grasses can be developed to flourish with less water. Also, industry can recognize that all processes using water should be altered to save water and reduce the size of the waste stream.

Increasing water supplies

Municipalities can increase available water through metering, leak detection and development of more sensible pricing policies, according to Lehr.

"Many cities still don't meter their water; they just offer users a flat rate for all the water they want," he says. "That's crazy. You can't conserve water if people have no idea about how much they are using. If there is no incentive for people to not waste water, they will waste it.

"The average American community loses nearly one-third of all of its water from leaks through its distribution pipes. Today, there are techniques to repair and eliminate leaks — such as insertion of plastic liners in pipes — that could help prevent the loss of great volumes of water.

"Furthermore, many communities that sell a lot of water actually encourage waste through reverse pricing. They offer a quantity discount — the more you buy, the less it costs. Pricing should be changed so that your first draws are cheap, then if you want more you pay more. That way, users will determine if they really need the additional water."

Even though home water use represents just 6 or 7 percent of total community consumption, public education about conservation may have significant benefits. "We need to make people aware of silly wasting of water in their own homes, like excessive lawn watering," Lehr says. "In addition to saving domestic water, public education has a psychological benefit. With the right mindset, people are more likely to vote for a bond issue, for example, that raises capital for a new leak detection or metering program. Public education convinces consumers that they are an important part of the solution."

Conservation at home means teaching people how to water their lawns; consumers should know how much water is really useful in turf maintenance. Many communities are implementing low-flow toilet programs. Years ago, toilets used 8 gallons to flush, but modern toilets can use 3.5 gallons, or 1.6 gallons, to flush without creating sewage impediments down the line. Also, as the public continues to use shower restrictors, low-flow cycles for washing dishes and clothes, and other conservation techniques, they realize they can get by comfortably with less water.

To emphasize the need for long-range planning and to communicate existing solutions to drought-related water management problems, the NWWA is helping produce a major joint venture conference and exposition. Program planning for Conserv '90 to be held in Phoenix, in August 1990, is co-sponsored by the NWWA, the American Water Works Association, the American Water Resources Association, and the American Society of Civil Engineers. These four professional associations have combined memberships of more than 170,000.

"We believe that Conserv '90 will be the biggest collective water focus meeting ever held in the United States," Lehr says. "This unprecedented event of technology and information sharing will be presented by conservation professionals who have water management solutions for the 1990s and beyond."

Conserv '90 will assist decision makers, people who make everyday decisions about how water is produced, distributed and consumed in the nation. But "we encourage and expect attendance from lawmakers, city managers, industrial engineers, environmentalists and, in fact, everyone in the United States who needs to prepare for the unavoidable national and regional changes in demand for and distribution of water

Seismic Risks Affect Water

After an earthquake, emergency crews are faced with fighting fires that break out as a result of broken gas lines downed electric lines and other quake-damaged structures. Their ability to save lives and property depends often on whether water pipelines survive the quake.

There has been a growing awareness of the need to design pipelines to withstand seismic events since the 1971 San Fernando, Calif., earthquake knocked out between 800 and 1,000 pipelines. The lessons of this quake have not been lost on the Metropolitan Water District of Southern California, which is making seismic conditions a top priority in developing a new pipeline that will interconnect the east branch of the California Aqueduct with the Colorado River Aqueduct.

The new pipeline will provide for the delivery of additional water to the 14.6 million people living in the district's six-county service area.

All possible routes for the feeder system cross or parallel major stretches of the San Andreas or other active faults. These routes originate northwest of San Bernardino at Devil Canyon Power Plant and terminate at the head of the San Diego Canal, about 40 miles to the south. Preliminary plans indicate the system may be a combination of existing and new lines, or may consist entirely of new pipes. In either case, the majority of the pipes will be underground, but portions of the line may be laid above ground or in tunnels.

The seismic risks led the district to undertake a comprehensive analysis of 17 different routes. Dames & Moore, Los Angeles, was retained to evaluate the seismic risks of each proposed route based on several variables, including different earthquake scenarios, the impact of separate seismic events, and the performance of two types of underground pipelines (steel and concrete) and one general class of tunnels.

The systems analysis was performed with the aid of a proprietary computer model known as OUTAGE, which was developed originally under a grant from the National Science Foundation. The model brings together data on seismic hazards, pipeline vulnerability, system topologies, and pipeline performance criteria.

Eight earthquake scenarios were selected for the modeling process — four were modeled along segments of the San Andreas fault, three along portions of the San Jacinto fault, and one along the length of the Cucamonga fault.

A key part of the analysis was to identify the specific route segments subject to earthquake-related outages and damages. The analysis was able to identify segments of the alignment of specific seismic concerns and determine the importance of pipe material to performance. Seismic vulnerability was measured by the expected number of repairs and the probability of failure. With this data, the district will be able to compare expected damage costs with construction costs and determine whether designing to a higher construction level would be warranted from an economic standpoint.

In addition, the firm advised the district on the general seismic design concepts aimed at mitigating earthquake damages in areas where the pipeline crosses faults or passes through soils susceptible to liquefaction.

resources in the next decade," Lehr says.

Continual supply problems

According to Lehr, Phoenix is an ideal setting for the conference. Located in a semi-arid desert climate, the nation's ninth largest city continually faces potential water supply problems. On the positive side, the city has developed one of the best water conservation programs in the country.

Phoenix is located within the northern reaches of the Sonoran Desert. The city experiences hot weather lasting about six months, summer temperatures that frequently climb over 100 degrees F, and an average rainfall of only 7 inches per year.

Within the past 100 years, historical records show that the Salt River Valley, from which the city receives most of its water supply, has experienced droughts up to 10 years in duration. In addition to addressing concerns about unreliable precipitation, the city faces many other pressures on its water supply including rapid population growth, restrictive state legislation, concern about water quality (particularly from contaminated groundwater wells), unresolved water rights claims, and reservoirs too small to hold runoff during wet years.

Brenda Chapman, water conservation coordinator for the city's Water Conservation and Resources Division, says, "Fortunately, Phoenix was in good shape during the national drought of 1988, although we did not reach top water production numbers of past years. However, if there is low snowfall this winter, we could face water shortage problems as soon as 1990."

According to Chapman, the key to weathering current and future droughts is implementing a comprehensive water conservation program — one that maximizes the efficiency of water use while assuring equitable impact on all customers.

Phoenix has had an aggressive conservation program since 1982. The program was initially designed in response to the 1980 Arizona Groundwater Management Act, which mandates that after the year 2025 users in Phoenix can no longer pump groundwater faster than the groundwater is naturally or artificially replenished. Groundwater has been a primary source in 400 of Phoenix's total 600 square miles of service area.

Relying on a variety of conservation measures, Phoenix's annual per capita consumption rate since 1982 has been reduced by more than 6 percent (the 1980 figure of 267 gallons per person per day was cut to 247 gallons per person per day in 1987). The water demand reduction resulted from a public awareness and education program, water rate increases and rate structure revisions, building code revisions requiring water conservation fixtures, and an emergency plumbing fixture retrofit program.

The public awareness program, initiated in 1982, educates businesses and individuals about wise water use. Information about low water use landscaping and irrigation is being disseminated to homeowners and developers.

The high profile public awareness and education program uses television and radio public service announcements, newsletters, bill inserts, billboards, bus signs, bus bench advertising, community and trade show exhibits, and presentations to professional and civic organizations. The program has a small advertising budget — $25,000 — but it has relied extensively on free local media coverage, as well as space donations from outdoor advertising companies. By the end of 1987, 4 million educational brochures were distributed, $240,000 was donated for public service air time, and Water Conservation Office staff participated in six trade shows and community festivals that attracted more than 500,000 area residents.

Chapman says that rate increases and

Mansfield Expands Water Treatment System

In 1983, Mansfield, Texas, had a population of 9,450. However, due to its strategic location between Dallas and Ft. Worth, this soon changed. By 1986, Mansfield had experienced a 7 to 8 percent growth spurt, which brought the population up to 14,658.

Unfortunately, what was good for the city economically boded ill for the city's water supply. Mansfield's water treatment plant could produce only 3 million gallons a day (mgd), which was not enough to satisfy the needs of its growing population. The city began looking at ways to expand its water treatment plant and the expansion plan it chose won first place in the water supply category of *American City & County's* 1988 Awards of Merit.

Award of Merit

Rather than adding on to the old treatment system, Mansfield hired Camp Dresser and McKee, Boston, to design a new system to work in conjunction with the old. The new system produces 7 mgd. Combined with the old plant's production capability, Mansfield now has 10 mgd of treated water for its population of 15,726.

According to Chris Burkett, director of planning developments and city engineer, the design of the addition easily lends itself to further expansion. "The next time we expand, we'll take the old plant out of service," he says. "If we duplicate the new plant adjacent to itself, we pick up another 7 mgd. We can get up to 56 mgd with more additions — all on the original four-acre site. Under the old system, with additions, we could have produced only 15 mgd on that site."

Funding for the expansion came from city revenue bonds issued in 1985. A $5.6 million allotment was provided, but the plant actually cost $4.9 million. Burkett attributes the savings to conditions brought on by statewide economic difficulties. "There was less work for the contractors so they bid cheaper," he says. "What was bad for them was good for us." The remaining $700,000 went toward improvements on the original plant.

An important feature of the new plant's design is the ability to add energy-producing turbines for utilizing incoming water pressure. The turbines will be cost-effective when water flows are at twice their current rate. They have not been installed yet, but Burkett says, "We've made provisions for them to be installed in the next stage."

The advent of this stage depends on Mansfield's population growth, which has slowed, and the Texas economy. "Hopefully the economy will pick up in the next seven years and we'll install them," he says.

For the present, "Mansfield is holding its own" economically and demographically, and the new water treatment system is providing ample water for its citizens.

Not content with a facility that was merely practical, Mansfield wanted it to be attractive as well. The plant was designed to be compatible architecturally with its surrounding community, which includes a school, a church, and a residential area. □

This article was written by Jennifer Carlile, editorial assistant for American City & County.

rate structure revisions are the most effective demand management tools.

"Phoenix raised its rates and revised its water rate structure to encourage water conservation among high-use customers. The water rate changed from almost flat rate to an increasing block rate schedule. Pricing policy changes helped us save 10,000 acre feet per year (9 million gallons) of water by 1985," she says. The Phoenix water system meters 99 percent of its water billed to customers, so there is little more to be gained.

Building code revisions, intended to reduce sewer flows, also helped conserve water. By 1985, partial compliance with the code saved the city approximately 2,000 acre feet per year (2 million gallons). Also, through an emergency retrofit plumbing fixture program, low-flow shower devices and toilet dams were installed in more than 40,000 homes.

"Overall, these demand management programs have reduced water demand by 22,000 acre feet per year, or 19 million gallons," Chapman says. "But more needs to be done if Phoenix is to achieve its goal of 10 percent per capita water demand reduction in 1990 and 20 percent reduction by 2000, as compared with 1980."

The newest strategies include plumbing codes that require use of 1.6-gallon flush toilets by 1991; promoting water-conserving, drought-tolerant landscaping; auditing large turf facilities; modifying the increased block rate structures; minimizing lost or unaccounted for water to less than 10 percent of water produced; and continuing development of public education programs.

"Additional augmentation of Phoenix's water resources and implementation of water conservation programs are necessary to provide adequate water supplies into the 21st century," Chapman says. "Resource augmentation activities — such as purchasing and to acquire associated water rights, reclaiming wastewater and recharging groundwater — will be expensive. To lessen the burden of the expense associated with resources augmentation, the citizens of Phoenix are helping us by effectively conserving water today."

Costs for administration and implementation of Phoenix's 1988-1989 water conservation programs will exceed $1.5 million.

Most of California suffered through extreme drought in 1988, and many regions of the state continue to have problems this year. Marin County, north of San Francisco, experienced the driest 32 consecutive months on record through February 1989. Ronald Johnson, general manager of the Marin Municipal Water District, says, "Until we received heavy rainfalls in March 1989, our reservoirs were down 50 percent or more from normal levels.

"During the recent most severe drought, our board of directors instituted measures requiring 35 percent water rationing, and also enacted an ordinance to ban new service connections until sufficient water supplies are available. In addition, we managed several ongoing conservation activities, such as installing low-flow showerheads and ultra low-flow toilets, checking our 830 miles of pipeline for leaks, restricting turf irrigation, instituting an inverted tier pricing system, and employing reclaimed wastewater for landscaping irrigation. Combined, all of these activities helped us achieve an 18 percent reduction in water use from May 1988 through March 1989," Johnson says.

Before the recent drought, Marin County spent about $300,000 per year on conservation programs and public education; 1988-1989 costs exceeded $500,000.

Voluntary conservation

Like many other cities and towns in Southern California, Pasadena instituted voluntary conservation measures in 1988; the measures resulted in an 8 percent reduction in water use. Mary Ann Long, the city's conservation coordinator, says that residents were asked to water lawns after 5 p.m. and every third day, use a shutoff valve when car washing, and stop filling or refilling swimming pools. Also, unless requested, no water was served in restaurants and filling decorative fountains and ponds was prohibited.

The Metropolitan Water District of Southern California now is offering a credit program through which Pasadena's conservation department will receive $75 for every acre foot of water saved.

Palm Desert, east of Los Angeles, began using drought-tolerant median landscaping in 1986. John Wohlmuth, senior administrative assistant for the

Shreveport Automates System

Shreveport, La., has installed four fully automated Rio Linda chlorine dioxide generators as a key part of the city's 1985 water and sewer capital improvements program about to near completion.

Two of the four fully automated chlorine dioxide systems went on line July 1, 1988. Thorough test results document chlorine dioxide yields of 95 to 98 percent. This is 20 to 23 percent better than the manual system previously used in Shreveport, and consistently higher than other types of chlorine dioxide generation systems available.

"There are lots of other ways to control off-flavors and odor, but unlike chlorine dioxide they can't also provide a powerful and long-lasting disinfecting residual throughout the almost 1,000 miles of our water system," says J.B. Williams, the superintendent of the water purification division.

All four generators, supplied by Fischer & Porter Company, Warminster, Pa., have microprocessor-based controls. Data from the automated operation of the systems will be uploaded to Shreveport's mainframe and PCs where it can be totalized.

In the early 1980s, under the advice of Black & Veatch, Dallas, the city installed manual chlorine dioxide generators. To keep pace with its population growth, Shreveport initiated its 1985 Water and Sewer Capital Improvements Program. This project added two new 5-million-gallon water storage reservoirs for increasing capacity to 93 million gallons per day, and an upgrading of the manual chlorine dioxide systems.

The Rio Linda system generates chlorine dioxide gas by automatically mixing sodium chlorite liquid and chlorine gas under vacuum. Adjusting the dosage also is automatic. Phillip Leon, chief supervisor of operations, says, "For Shreveport, fully automated generation and dosage means lower chemical costs, higher yields, increased safety, and the ability to totalize our data."

Because operating and maintenance costs of chlorine dioxide are low compared to other disinfection methods, Shreveport was able to install four chlorine dioxide generators. The generators are rotated in and out of service two at a time, allowing routine maintenance to be performed with no downtime.

According to Williams, "Facilities are at 65 million gallons per day. With the two new 5-million-gallon water storage reservoirs, we will reach 93 million. The expansion is primarily for projected population growth. We don't want to expand too late. We want the same high quality of water we have now to stay with us as we grow. Also, we already have some major industries around here that require good water, and hopefully our abundant supply will attract more. The quality of our water allows most industries to use it for their processes without treatment." □

city, says the program has been quite successful.

"The city is now installing green, lush drought-tolerant landscaping on street medians over a three-mile area," he says. "Also, the city council has approved the use of drought-tolerant landscaping in front of developments and buildings, instead of grass, palms and other oasis-looking materials. We have determined that grass and palms cost about 16 cents per square foot to maintain versus only 4 cents per square foot for drought-tolerant materials."

Cities and counties in the arid Southwest were not the only localities hurt by last year's drought. Hugh Wilkins, water plant supervisor for Great Falls, Mont., says that while 1988 was an extremely dry year for his city, it was made worse because the municipal water plant was under construction.

"The Missouri River, our source of potable water, was down 2 feet in 1988. What mitigated the problem is that our customers are metered, and metering helps prevent the wasting of water. Now people check the weather forecast to see if it is going to rain before they irrigate crops," he says.

"Two drought-related problems were water aesthetics and smoke. We had a lot of algae blooms in the hot, dry summer of 1988; as a result, people complained about taste and odor in their

Off-Peak Pumping Reflects Savings

DeKalb, Ill., has been pumping its drinking water off-peak for almost a year, a practice that shows promise of meeting an expected $150,000 reduction in annual electrical costs for the city's water division.

Electric bills averaged $248,881 in the five-year period between June 1983 and June 1988. The 1989 bill is projected to total $102,600. That is a savings of $146,281, or 59.8 percent of the gross electric bill, and a savings of 64.6 percent on the potable water pumping portion of that bill.

Off-peak pumping is possible because of a two-year building program. This includes construction of two elevated storage tanks with capacities of 2 million gallons each, two 1,200-gallon-per-minute wells, about six miles of new water mains, and the installation of an automated and computerized control system.

DeKalb's updated water system serves 33,000 citizens, Northern Illinois University (the second largest university in the state), and a growing business/industry contingency. Daily consumption averages 4.2 million gallons.

Each of DeKalb's elevated storage tanks hold 2 million gallons of water.

The project was financed through a 20-year, $5.3 million general obligation bond issue and a user rate increase. The rate increase was imminent even if the improvements had not been made. □

This article was written by Ron Naylor, director of public works for DeKalb, Ill.

water. Also, the city was enshrouded in smoke all summer due to major forest fires in surrounding areas," he says.

Great Falls received a record 76 inches of snowfall this past winter, so Wilkins does not expect drought problems in 1989. However, he is concerned about burnoff from the great fires at Yellowstone National Park, located about 150 miles from the city. The smoke from Yellowstone has contaminated the Gelatin River, the Madison River, and the Yellowstone Basin, all of which flow to Great Falls by way of Missouri River drainage.

Bill Teie, assistant deputy director at the California Department of Forestry and Fire Protection, says the state had more fires and more fire damage than usual because of the 1988 drought. "The state spent tens of millions of dollars to fight fires; the money was needed to add extra people to engine companies, to keep aircraft on hold longer than in normal years (firefighting helicopters generally are dismissed in the early fall), and to move resources back and forth in anticipation of new fires," he says.

Much of the Midwest, including many Chicago suburbs, were watershort in 1988. In Oak Brook, a Chicago suburb, the community's 7,300 water customers managed to drain dry all three of the city's reserve storage tanks over one weekend last June. Daily consumption increased from less than 4 million gallons to 9 million gallons. Because the suburb's five wells could produce only 6 million gallons daily, Public Works Superintendent Tom Lane placed a ban on washing cars and filling pools. Lawn sprinkling was limited to a maximum of 12 hours weekly.

Lane says that the city now is drilling a new 1 million-gallon well and also is building a new 7 million-gallon reservoir, which will double Oak Brook's reserve storage capacity.

Unlike Oak Brook, many other Chicago suburbs are reluctant to make extensive improvements because they are scheduled to get water from Lake Michigan in a diversion beginning in 1992. But Daniel Injerd, a water resources specialist for the state says that Illinois intends to get stingier about removing water from Lake Michigan. He says the state also may require — rather than encourage — all cities tapping into diversion water to adopt laws restricting lawn sprinkling and other outdoor water uses.

Wastewater reclamation

Pasco County, Fla., just north of Tampa, has developed a regional wastewater reclamation program that attacked both increased sewage treatment needs and diminishing water supplies. Two new treatment plants will expand the county's sewage treatment capacity. When completed, the county will dispose of treated effluent at one of two percolation pond sites near one of the treatment plant sites, allowing effluent to recharge the local groundwater once it percolates through the soil. Local golf courses will serve as land application sites.

"Applying the effluent to golf courses actually achieves a higher degree of reuse," says Wayne Welch, CH2M Hill's project manager. "By using effluent in place of potable water for spray irrigation, golf course operators recharge drinking water supplies rather than deplete them. Recharge also helps prevent saltwater intrusion of groundwater from the Gulf of Mexico."

Bruce Adams is director of land and water planning for the South Florida Water Management Authority, which serves a 17,000-square-mile region south of Orlando from east to west coast. Adams also is national president of Xeriscape, a program to achieve water conservation through use of drought-tolerant landscaping.

"In south Florida, like much of the Southeast and West, we must find better ways to balance the rising water demands of a growing population with the reality of limited water supplies," he

says. Many parts of Florida were hit hard by the recent lack of rainfall; through March of 1989, total precipitation was only 43 percent of normal. As a result, many municipalities instituted mandatory 15 to 30 percent cutbacks in water use.

Much of Florida relies on groundwater supplies; unfortunately, the water generally comes from shallow aquifers. Thus, drilling deeper wells will not help solve shortage problems.

To help reduce water demand, Adams advocates use of creative conservation programs. "Xeriscape originated with the Denver Water Department in response to severe 1981 drought conditions; the program's principles were further developed through experience in a number of semi-arid western states," he says.

"The term Xeriscape simply means using water conserving, drought-tolerant materials that do not require special attention to grow properly. Xeriscape materials will survive and flourish with comparatively little supplemental irrigation. Approximately one-half of the per capita water demand in urban areas of south and central Florida is for outdoor use. Application of Xeriscape landscaping, using materials such as oaks, pines, citrus, daylillies and many palms, can significantly reduce outdoor water use," he says.

With reservoir levels at just 55 percent instead of the normal 91 percent, New York City Mayor Edward Koch declared a wide range of drought emergency measures on March 22, 1989.

Warning that "New York will not be as green as usual this year," the mayor said, "we are banning or cutting back on the non-essential use of water in order to keep the reservoirs as full as possible. All of us have to comply with the restrictions and change our personal habits at home. Just observing these new restrictions is not enough. New Yorkers must use as little water as possible in their daily lives. The city is depending on its citizens to pull through this crisis."

New York's mandatory restrictions include a ban on watering lawns, shrubs and gardens; a mandatory 20 percent cutback in water use by all businesses; a ban on washing any vehicle with a hose or with water from a hydrant; a ban on washing down sidewalks, driveways, steps or the exteriors of buildings; a ban on the ornamental use of water, including fountains, waterfalls and reflecting pools, even if these recirculate the water; a requirement that commercial car washes use well water; and a ban on filling private swimming pools.

The various restrictions have enforcement fines ranging from $100 to $1,000 for repeat violators.

Plans are under way for the city to pump up to 100 million gallons a day of Hudson River water to augment reservoir supplies. The city also is stepping up a long-term metering program. Its 10-year plan calls for installation of 600,000 residential water meters. All commercial and industrial buildings already have meters.

"The immediate drought cannot be stopped or slowed by human intervention," says a NOAA publication. "Cloud seeding, for example, will not work where there are no clouds or where clouds and the surrounding environment fail to meet critical specifications; and drought areas do not produce the appropriate conditions."

American cities and counties cannot change the meteorological aspects of the drought, but they are beginning to create a new climate for change. By modifying human behavior, planting the seeds of conservation and intensifying long-term water resource planning, local governments are helping to slake the great national thirst of 1988-1989.

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National Water Policy: A Prospect for Institutional Reform

Stephen S. Light and John R. Wodraska, South Florida Water Management District

Stephen M. Born, ed., *Redefining National Water Policy: New Roles and Directions* (Bethesda, MD: American Water Resources Association, 1989), 91 pp.; $9.00.

Leonard B. Dworsky, Ronald M. North, and David J. Allee, eds., *Water Resources Planning and Management in the United States Federal System* (Henniker, NH: Engineering Foundation Conference, 1988), 148 pp.; $5.00.

Charles H. W. Foster and Peter P. Rogers, *Federal Water Policy: Toward An Agenda for Action* (Cambridge, MA: Discussion Paper, Harvard University Energy and Environmental Policy Center, Harvard University, 1988), 109 pp.

Interstate Conference on Water Policy, *Toward National Water Policy Coordination: The Challenge of Improving Intergovernmental Relations* (Washington: Interstate Conference on Water Policy, February 1990), 7 pp.

Western Governors Conference, *White Paper: Federal Water Policy Coordination* (Denver, CO: Western Governors Conference, May 1989), 11 pp.

The decade of the 1980s was rather turbulent for those in state and local water management. The President and Congress, by changing fiscal policy and eliminating programs, shifted additional water-related responsibilities to state and local governments. In addition, supporters of improved intergovernmental relations witnessed the demise of the Water Resources Council (WRC) and the River Basin Commissions (RBCs) in 1981. Almost ten years later, no alternative mechanism has emerged for overseeing intergovernmental and interagency issues dealing with national water policy.

One Washington, DC reporter became so frustrated with the lack of leadership from the federal government that he wrote, "In Washington, D.C., federal water policy does not exist, except as a joke."[1] In the same article a staff director in the U.S. House of Representatives was quoted, "We have gone through eight years of non-leadership on water issues."[2] While many share this perspective, others have welcomed the federal hiatus and viewed it as an opportunity for the states to reassert themselves in the water policy arena. In fact, researchers throughout the nation have been documenting in watersheds under stress, a new wave of policy and institutional innovations at the subfederal level (Born, 1989). While these changes have been viewed positively, such assertive behavior has created additional controversy and strain on intergovernmental and interagency relations. Federal responsibilities have not been obviated by this trend in water policy, but respective governmental roles are being reexamined.

Disputes among various agencies and levels of government have increased in frequency as more public entities have asserted jurisdiction over the same water-related resources. Ironically, these same agencies and levels of government have become even more dependent on each other for information, technical capability, and policy decisions, as fiscal resources have become increasingly scarce.

The nature of the federal system of government is another source of irritation. The separation of governmental powers and responsibilities is a cherished part of the nation's political fabric and democratic system. However, from a water management perspective, when resource problems require a larger-than-local perspective, by its very nature the federal system has frustrated efforts to develop a unified vision and has presented formidable obstacles to intergovernmental collaboration. The absence of true incentives for improved economy, efficiency, and evenhandedness in intergovernmental coordination has been yet another part of the problem (Foster and Rogers, 1988, pp. 89).

Collectively, these factors have contributed to the perception that the nation is becoming a victim of its own institutions—that the nation's institutions have been losing their problem-solving capacity.[3] Concern has grown over the lack of marked gains in achieving the nation's collective ends in managing water resources, and particularly over the adverse impact that poor state-federal relations have had on this problem.

This article traces the evolution of deliberations on national water policy coordination over the past five years. It begins with a retrospective view of the Water Resources Planning Act (WRPA) in Henniker, New Hampshire, where the Engineering Foundation Conference was held in July 1986. It concluds with and looks just beyond the 1990 Interstate Conference on Water Policy in Washington, DC, where debate ensued on a specific proposal to reestablish a water council in the executive branch. This condensed analysis is just one interpretation of the material covered. Readers are encouraged to review the documents and to draw their own conclusions. Primary attention is given to the following questions:

- Is the intergovernmental relations problem in national water policy more serious than apparent or more apparent than real?
- Some contend that the nation will not face a water crisis in the 1990s but will continue to endure a crisis in leadership throughout the decade. The question is—where will the requisite leadership come from to restructure national water policy?