STAFF REPORT

Report To: Board of Supervisors **Meeting Date:** November 16, 2017

Staff Contact: Darren Schulz, Public Works Director

Agenda Title: For Possible Action: To provide recommendation to the Bureau of Land Management (BLM) regarding the sale of fourteen parcels located in the Pinion Hills neighborhood (APNs 010-082-04; 010-083-06; 010-084-03; 010-084-02; 010-087-05; 010-087-06; 010-087-07; 010-087-08; 010-093-03; 010-094-02; 010-093-05; 010-097-02; 010-098-01; and 010-098-02) identified for disposal in the Omnibus Public Land Management Act of 2009 (OPLMA). (Stephanie Hicks; SHicks@carson.org)

Staff Summary: As a result of three years of collaboration between City officials, interest groups and Congressional delegates with technical input from Federal agencies, OPLMA was signed by the President of the United States in March 2009. The OPLMA legislates that certain BLM properties are to be offered for sale through a competitive bidding process. Criteria for identifying such parcels included that the parcels be located adjacent to existing development and at the "urban interface" with development making them isolated and difficult to manage by BLM. Fourteen parcels in the Pinon Hills were identified for future sale. These parcels are zoned Single-Family–1 Acre with a Low-Density Residential master plan designation. BLM is seeking Carson City's recommendation for sale.

Agenda Action: Formal Action/Motion **Time Requested:** 20 minutes

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Proposed Motion

Move to direct staff to forward to BLM the recommendation for disposal of fourteen parcels located in the Pinion Hills neighborhood (APNs 010-082-04; 010-083-06; 010-084-03; 010-084-02; 010-087-05; 010-087-06; 010-087-07; 010-087-08; 010-093-03; 010-094-02; 010-093-05; 010-097-02; 010-098-01; and 010-098-02) in accordance with the provisions of the Omnibus Public Land Management Act of 2009 as presented by staff.

Board's Strategic Goal

Quality of Life

Previous Action

December 3, 2009. Possible Action: To direct to provide recommendations to the Bureau of Land Management (BLM) regarding the sale of certain BLM properties identified for disposal in the Omnibus Public Land Management Act of 2009, APN's 9-032-03, 10-061-77, 10-062-60, 10-064-01, 10-082-04, 10-083-06, 10-084-02 and -03, 10-087-05, -06, -07 and -08, 10-093-03 and -05, 10-094-02, 10-097-02, 10-098-01 and -02, 10-192-04, and portions of APN's 8-011-19, 8-521-20, 9-301-01, and 9-273-02. Motion Approved 5-0.

Background/Issues & Analysis

On January 6, 2009, the "Omnibus Public Land Management Act of 2009" (OPLMA) was enacted by Congress to determine the desired future uses of Federal properties surrounding Carson City. This bill was the result of three years of collaboration between City officials, interest groups and Congressional delegates with technical input from Federal agencies. During this time, there was a vigorous and extensive citizen participation program consisting of more than 15 public information workshops and advisory board meetings where opportunities were available to present written comments or where oral and written testimony was received.

The bill provided for the disposition of more than 8,000 acres of Federal lands within Carson City, including the sale of approximately 150 acres of Federal land by BLM. The Act required that the lands be sold within one year of the enactment of the Act unless Carson City postponed or excludes the property from sale. The purpose of the bill was to improve land management throughout Carson City and help fulfill the community's long-term plan for growth and conservation. During that process, these parcels were identified for sale.

The OPLMA was signed by the President of the United States in March 2009. On December 3, 2009, the Carson City Board of Supervisors approved a request from the Planning Division to delay the sale of all of the Pinion Hills parcels until market conditions improve and in order to explore options for the disposal of the parcels. Some of the parcels do not have access to the property frontage and have other topographic constraints.

Since that time, City staff has received numerous requests about the sale of these parcels. In July 21, 2016, one of the fourteen parcels was brought to the BOS due to interest expressed by potential buyers. Adjacent property owners attended the meeting and expressed concerns regarding drainage issues, water quality and quantity issues, recreational use of the property and effects on the natural environment. The item was tabled so that the homeowners and Public Works' staff could meet and discuss further. Following the meeting, staff and BLM met with the property owners to explain development requirements and the sale process. The property owners indicated they had a better understanding and would not be opposed to the sale.

At the suggestion of BLM, future attempts to sell this parcel would be better spent by bringing multiple parcels forward at one time. Therefore, a determination was made to bring all fourteen parcels forward for recommendation to the Board.

A Major Project Review was held on July 18, 2017, to determine whether there were any City-wide needs or requirements for the parcels. It was determined that there were no City-wide needs and there was discussion regarding future residential development and building requirements. The parcels are zoned SF1A (Single-Family 1 acre) with a master plan designation of low-density residential. Allowable uses include a single-family residence or a park. Accessory uses include accessory farm structures, accessory structures, agricultural use, animals and fowl, guest building, home occupation and individual or subdivision recreation use (swimming pool, tennis court).

If developed, all parcels will need to accommodate natural drainage. Some of the parcels will need formal drainage and access easements for existing drainage facilities. There is no sewer and water available; therefore, the parcels will need to meet requirements for well and septic. New wells must be approved by the City and State and meet all requirements. Paved access will be required at time of the development if it is not already present. Some parcels may be dividable. However, each parcel would have to be evaluated and if divided, a denitrifying septic system would be required. If a parcel is divided or it serves more than four parcels, the road would have to be brought up to City standards.

There are no mapped flood hazards for these parcels. However, all parcels will need to accommodate natural drainage. Some of the parcels will need formal drainage and access easements for existing drainage facilities.

On August 29, 2017, City and BLM staff held an Open House to collect feedback from the neighborhood and to answer questions about the process and allowable uses prior to bringing this item forward to the Board of Supervisors for direction. 103 notices were mailed to neighborhood residents. Sixty-three residents attended the meeting. Staff provided an overview presentation and then took questions. Residents expressed concerns regarding drainage issues, recreational use of the property and effects on the natural environment. However, the primary opposition was due to water quality and quantity issues. Approximately half of the attendees indicated this was their main concern. Staff requested that comments be submitted in writing so that they could be provided in the staff report. To date, staff has received comments from 18 residents, 17 in opposition of the sale. All comments received have been attached to the staff report.

Staff has contacted the Division of Water Resources which indicated that there are no known water quality or water quantity issues in the area. Staff also reached out to the United States Geological Survey (USGS) to review any ground water monitoring well records in the area and report any known or any unknown water quality issues. Staff plans to have USGS report on findings at the Board of Supervisors' meeting.

These parcels are located adjacent to existing development and at the "urban interface" with development making them isolated and difficult to manage by BLM. The sale of these parcels will create continuous land management units, is consistent with BLM's management plans and the Carson City Master Plan, and reduces the "checkerboard" ownership pattern of Federal, City, and private lands.

Should the recommendation for sale be approved, BLM will pursue sale of the parcels at no less than fair market value through an open competitive bid process. First right of refusal cannot be provided to adjacent property owners. The process will take approximately two years to complete. Funds from the sale will be used to cover the BLM's costs for processing the sales. After this deduction, the legislation directs the Secretary of Interior to reinvest the remaining proceeds of these land sales back into important public projects. Ninety-five percent of the proceeds will be used to acquire environmentally sensitive lands and protect archaeological resources in Carson City. The remaining five percent of the proceeds will go to Nevada's general education program. None of the proceeds go directly to Carson City.

Applicable Statute, Code, Policy, Rule or Regulation

Omnibus Public Land Management Act of 2009.

Financial Information

Is there a fiscal impact? ☒ Yes ☐ No

If yes, account name/number: Potential property tax revenue.

Is it currently budgeted? ☐ Yes ☒ No

Explanation of Fiscal Impact: The cost of the sale of the subject Federal properties is the responsibility of BLM, per the Act. The sale of the properties will have a positive impact to Carson City revenue through an increase in property taxes collected on the properties when they are in private ownership.

Alternatives

Do not direct staff to forward to BLM the recommendation for disposal of these parcels in accordance with the provisions of the Omnibus Public Land Management Act of 2009 as presented by staff.

Direct staff to forward to BLM the recommendation to delay the disposal of these parcels in accordance with the provisions of the Omnibus Public Land Management Act of 2009 as presented by staff.

Modify the recommended motion.

Board Action Taken:

Motion: ______________________ 1) ______________ Aye/Nay

2) ______________ ________

____

(Vote Recorded By)

From: Steve Rose
To: Stephanie Hicks
Subject: Re: BLM Parcels and Carson City management of sales
Date: Monday, August 21, 2017 10:48:52 AM
Attachments: image001.jpg

Thank you Steve

On Mon, Aug 21, 2017 at 10:46 AM, Stephanie Hicks <SHicks@carson.org> wrote:

> Mr. Rose:
>
> Thank you for your response to the invitation for the open house. As we indicated in the invitation, our goal is to collect feedback from the residents and answer any questions you may have. Therefore, I very much appreciate you providing your list of concerns in advance of the meeting. I will research any answers I don't have so I can adequately address them for you at the open house.
>
> I look forward to meeting you on August 29th and appreciate your participation in this matter.
>
> If you have any other questions, please do not hesitate to let me know.
>
> Thank you.
>
> Stephanie Hicks, AICP, CFM
>
> Real Property Manager
>
> Carson City Public Works
>
> 3505 Butti Way
>
> Carson City, NV 89701
>
> (775) 283-7904

From: Steve Rose [redacted]
Sent: Monday, August 21, 2017 8:39 AM
To: Stephanie Hicks; Nick Marano; Bob Crowell; Greg Hendricks; Margie
Subject: BLM Parcels and Carson City management of sales

I am in receipt of your letter dated August 16, 2017 regarding the intent by the Blm and Carson City to sell parcels on the eastern border near the river. I will be in attendance at the meeting on August 29,2017 and will ask my legal council to join me. I will be posing the following questions and concerns.

1. Why are these parcels being sold when the BLM controls 80% of all of the land in Nevada which constitutes hundreds of thousands of acres? What is the justification?

2. Where are they listed and advertised? I notice traffic up and down my road now.

3. Why is Carson City managing this as its federal land? And why do you support it?

4. Have they been surveyed? I have not seen a person out there and I'm a retired vet and home all day.

5. What are the prices? How were they comped? Residents should get the right of first refusal in this type of case on land that is up against there property line.

6. Has an environmental impact study been done? Impact on wildlife? Impact on residents?

7. Does the BLM or City know that the water table has dropped causing well issues?

8. Are new roads going to be installed? Currently the city does not maintain Mallow road

or fix issues with it and traffic would increase while development occurs and when housing is built.

9. Cost to residents is to lower value of property depending on guidelines and required codes. Heavy equipment working the area next to our homes, noise and loss of privacy issues.

10. there is a 100 year flood channel across some of these lots as was pointed out to me and had to be addressed when I built my home 10 years ago. Its on city maps and must be considered as it has flooded in the past year.

11. Is the city prepared to defend these issues legally? Without studies and knowledge of the area there cannot be a sale and development of lots approved.

12. Personally I intend to fight this sale and development legally and consistently as there has been no consideration for the problems with land, water, privacy and environmental impact. I'm sure you will see a large turnout to address this development without facts or studies.

See you at the meeting. Steve Rose // Mallow road

From: Steve Rose
To: Stephanie Hicks
Subject: Re: Pinion Hills Meeting August 29, 2017
Date: Wednesday, August 30, 2017 1:16:18 PM

Thank you Stephanie. SR

On Wed, Aug 30, 2017 at 1:15 PM, Stephanie Hicks <SHicks@carson.org> wrote:

> Mr. Rose:
>
> It was very nice to meet you last night. We were pleased with the turn out and feedback. The City Engineer and I will be researching the questions that came up regarding water quality and quantity so that we can properly advise the residents and the Board of Supervisors.
>
> To answer your other questions, I have attached a copy of the Fact Sheet we prepared for the meeting in the event you did not get a copy last night. Per the City's current development standards, any new residences would either be required to provide a paved driveway access or improve the roadway to county standards. The later would be trigger by dividing the parcel or if the access serves more than four parcels . These costs would be borne by the purchaser/builder of the residence. Although none of these properties are located in a FEMA mapped flood zone, all of the parcels would need to accommodate natural drainage. Some of the parcels will need formal drainage and access easements for existing drainage facilities.
>
> BLM is looking into the question about first right of refusal to determine whether this could be permissible. It does not appear that the Federal legislation spoke to that so it may be an internal procedure they have some discretion with.   BLM is also responsible for processing of the sale including environmental studies, survey needs, and appraisals. Their costs associated with these expenses will be reimbursed from any sale.
>
> Please feel free to call me to discuss anything further. The comments and questions we have received will be included in the report we bring forward to the Board.
>
> Thank you again for providing your input on this matter.

From: Steve Rose [redacted]
Sent: Wednesday, August 30, 2017 7:47 AM
To: Stephanie Hicks; Karen Abowd; Nick Marano; Bob Crowell; Janice Stillions; Greg Hendricks; Margie
Subject: Pinion Hills Meeting August 29, 2017

Good Morning--thank you Stephanie for holding the meeting of the neighborhood in the area under consideration for new home lot development. I know you now see, based on about 50 people showing up, that this is a very bad idea. The issues are severe when it comes to water table and quality. When you asked the question "how many are here due to water/changes shortages or concerns" all 50 hands went up. (many of us have hot water wells and have to buy systems to cool them down)

I built my home 10 years ago and was told the water would be hit at 110' approximately and we drilled to 265 feet. Many people have had to redrill wells due to a dropping water table and more usage could be a disaster for the homeowners in this area.

In addition the wells are hot water, hard water and have minerals and other issues that actually ate through the pipes in my well and had to be replaced.

I have installed thousands of dollars worth of filtering systems, reverse osmosis and treatments so it is safe and drinkable (I hope)

Kirby talked about cancers and I don't know the causes for all of the deaths but I do know that at least 4 people died of cancer out here in the past 10 years and that would indicate an issue to me and a need to get the state of Nevada off its butt and checking things out. They say there are no issues but have not done tests with anyone I know of out here.

It may be an issue for the State and the EPA to get involved in and do some serious analysis.

Other questions I did not get to ask as everyone was talking about water and non stop trying to get a word in are as follows:

Are you planning new roads? How paid for?

How does that impact property taxes?

There are flood runoff channels on some of the lots shown on Carson City Maps and have to be addressed.

If it comes to a sale right of first refusal should go to adjoining neighbors and needs to be guaranteed.

Can Carson City really afford to do this? the costs for studies, legal issues and support could be dramatic.

I have always been a proponent of our city and the smart things it does. I like the fact that we have veterans in our top spots and we treat veterans with respect and try to help them. Man of us out here are retired, Veterans and Baby boomers and we don't need the hassle of dealing with water issues, construction issues, traffic and noise. I would suggest that the board of Supervisors who are the final word on this we are told really think hard about creating a very negative impact on us out here. I appreciate your consideration and hope you will do the right thing.

Steve Rose/Vietnam Veteran (Recruiter for jobs for Veterans)

6060 Mallow road

Carson City, Nv 89701

From: Stephanie Hicks
To: "Merlyn Paine"
Subject: RE: Pinion Hills OPLMA lot transfer - Feedback
Date: Tuesday, August 29, 2017 2:26:43 PM

Good afternoon:

Thank you for your email. I do hope you will be able to attend the open house where we will be discussing these issues. We appreciate your concerns.

From: Merlyn Paine [redacted]
Sent: Tuesday, August 29, 2017 12:09 PM
To: Stephanie Hicks
Subject: Pinion Hills OPLMA lot transfer - Feedback

This message originated outside of Carson City's email system. Use caution if this message contains attachments, links, or requests for information.

Stephanie Hicks
Real Property Manager
Carson City Public Works
3505 Butti Way
Carson City, NV 89701

8/29/2017

Via email.

Ms. Hicks:

This letter is in response to your letter to the property owners in Pinion Hills, dated August 16th, 2017.

Opening development on fourteen parcels in my immediate property area concerns me greatly. Property owners here are all on wells, most of them geothermal, and the aquifer supply is already significantly declining.

My husband and I bought our property in late 1994; at that time, our well was drilled to 235 feet into the ground, and the static water pressure was 170, with a artesian gallons per minute rate of 20 p.s.i. When the well pump was replaced in April, 2013, the static water pressure had dropped to 182 feet below the surface. The artesian rate was then 10 gallons per minute. Please see the attached well measurement records from our time of purchase, 1994, and from our recent well pump replacement in 2013.

You can clearly see that the water level has dropped TWELVE feet and the natural artesian pressure has been HALVED in this 22 years. During this time, numerous houses have been built in this immediate area, and as you are aware there are no water restrictions as we are on private wells. Thus, any homeowner can use as much as his well can provide if s/he so chooses (one neighbor has a large lawn that is sprinkled thoroughly each day as I am aware).

The City has declined to bring out water and sewer to our area and as we own property and pay our taxes to the city, you have a responsibility to see that we are not disadvantaged by your taking over these fourteen parcels and wishing to sell them.

I'm sure that you are also aware that this region is both warming and becoming drier. Over the time I have lived here, east of the Carson River, our rainfall has declined from about 7-8 inches per year, to just 3.5 inches per year. Our aquifers need this space as open land (NOT water consumers) to resupply the aquifers.

Thank you for your attention.

Merlyn L. Paine

Parcel 010-087-16

X✓

WHITE—DIVISION OF WATER RESOURCES
CANARY—CLIENT'S COPY
PINK—WELL DRILLER'S COPY

PRINT OR TYPE ONLY
DO NOT WRITE ON BACK

STATE OF NEVADA
DIVISION OF WATER RESOURCES

WELL DRILLER'S REPORT

Please complete this form in its entirety in accordance with NRS 534.170 and NAC 534.340

OFFICE USE ONLY
Log No. 46729
Permit No.
Basin 103

NOTICE OF INTENT NO. 26819

1. OWNER Gary Hembree Const.
MAILING ADDRESS 306 Ruby Ln. Carson City NV 89701

ADDRESS AT WELL LOCATION 6025 Pursia Carson City NV 89701

2. LOCATION NE ¼ NE ¼ Sec. 23 T. 15 N/S R. 20 E Carson City County
PERMIT NO. (Issued by Water Resources) 10-087-15 (Parcel No.) Pinion Hills (Subdivision Name)

3. WORK PERFORMED
☑ New Well ☐ Replace ☐ Recondition ☐ Deepen ☐ Abandon ☐ Other

4. PROPOSED USE
☑ Domestic ☐ Irrigation ☐ Test ☐ Municipal/Industrial ☐ Monitor ☐ Stock

5. WELL TYPE
☐ Cable ☑ Rotary ☐ RVC ☑ Air ☐ Other

6. LITHOLOGIC LOG

Material	Water Strata	From	To	Thickness
Overburden		0	3	3
DG Sands		3	36	33
Large Volcanic Gravels		36	125	89
Tight Volcanic Clay		125	145	20
Small Volcanic sands		145	183	38
Large Gravels	XXX	183	235	62

'94 NOV -2 PM 1:53

Date started 10-27, 1994
Date completed 10-31, 1994

7. WELL TEST DATA

TEST METHOD: ☐ Bailer ☐ Pump ☑ Air Lift

G.P.M.	Draw Down (Feet Below Static)	Time (Hours)
	25	3HRS

8. WELL CONSTRUCTION

Depth Drilled 235 Feet Depth Cased 235 Feet

HOLE DIAMETER (BIT SIZE)

Inches	From (Feet)	To (Feet)
10 1/4	0	50
9 7/8	50	235

CASING SCHEDULE

Size O.D. (Inches)	Weight/Ft. (Pounds)	Wall Thickness (Inches)	From (Feet)	To (Feet)
6 5/8	13.03	.188	0	235

Perforations:
Type perforation Mill Slot
Size perforation 3 X 3/32
From 195 feet to 235 feet
From feet to feet
From feet to feet
From feet to feet
From feet to feet

Surface Seal: ☑ Yes ☐ No
Depth of Seal 50
Placement Method: ☐ Pumped ☑ Poured
Seal Type: ☑ Neat Cement ☐ Cement Grout ☐ Concrete Grout

Gravel Packed: ☑ Yes ☐ No
From 50 feet to 235 feet

9. WATER LEVEL
Static water level 170 feet below land surface
Artesian flow G.P.M. 20 P.S.I.
Water temperature Hot °F Quality Good

10. DRILLER'S CERTIFICATION
This well was drilled under my supervision and the report is true to the best of my knowledge.

Name A&H pump Company (Contractor)
Address 5551 Hwy 50 E #3 Carson City NV 89701 (Contractor)
Nevada contractor's license number issued by the State Contractor's Board 31839
Nevada driller's license number issued by the Division of Water Resources, the on-site driller 1905
Signed Michael L Haak (By driller performing actual drilling on site or contractor)
Date 11-1-94

(Rev. 3-91) USE ADDITIONAL SHEETS IF NECESSARY (D)-437

KAWCHACK
PUMP & WELL SERVICE, INC.
P.O. Box 901 ■ MINDEN, NV 89423
(775) 267-2150
CONTRACTOR'S LICENSE # 0021268

DATE: 4/8/13

INVOICE: 14413

BILL TO: Merlyn Paine
6025 Pursia
Carson City NV.

CONTACT: JOB SITE: Same

PH: 888-9015 CELL: 315-6725 FAX:

WELL SIZE/DEPTH	PUMP SETTING	PIPE SIZE	TANK SIZE	PUMP MAKE	PUMP D CODE
6" / 226'	212'	1"	WX-350	Grundfos	
STATIC WATER LEVEL	**PUMPING LEVEL**	**GPM**	**WIRE #–TYPE**	**PUMP MODEL**	**MOTOR D CODE**
182		10	10/3 Twist	106PM	1HP 1PH

SERVICE DESCRIPTION: 1st trip 1Hr. CK system short down well. 2nd trip Pull pump replace 42' of pipe, New wire, pump, add air to pressure tank

	QTY	MATERIALS	AMOUNT	
1.	1	1HP 106PM Grundfos Pump/Motor List 1311.00	1190	00
2.	42'	1" Galv. drop pipe List 3.10 ft.	117	60
3.	1	1" Flomatic check Valve List 38.00	32	00
4.	210'	10/3 w/G Sub Wire	346	50
5.	1	Torque Arrestor, Splice Kit, tape	24	00
6.	1	1 HP Control box	56	00
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				

TERMS OF SALE AND PAYMENT

Seller requires payment by check or cash. Payment in full is due upon receipt of this invoice. Failure to pay in full within 10 days of receipt of invoice will result in a finance charge of 2% per month (24% per annum) PLUS any other collection costs incurred. There is a $40.00 charge for returned checks. Seller, for security purposes, retains title to described goods until PAID IN FULL in case of buyer's default in payment. Seller or his agents may take possession of, and remove described goods from Buyer's premises without prior notice. In default, buyer waives all rights of action for trespass, damages or other cause resulting from repossession.

MATERIALS	1766	10
TAX CC	132	02
LABOR 6 Hr.	630	00
TOTAL AMT DUE	$2528	12

THANK YOU

From: Margie Quirk
To: Stephanie Hicks
Cc: Bob Crowell; Karen Abowd; Brad Bonkowski
Subject: Upcoming meeting regarding BLM/City Land
Date: Friday, August 25, 2017 11:39:28 AM

Hi Stephanie,

We are residents of the Pinion Hills. Our property backs up to the biggest parcels available for the city to sell for housing. We will be in attendance at the meeting, but wanted to put in writing that we oppose this action by the city.

Our biggest concern is water. What will happen to our water table if this many homes are built? There has already been talk of implementing meters on our wells. One resident has left his home and moved to Dayton as his well has gone dry. Why bring in more homes that will have an even bigger impact on the existing resources?

With all the other development going on in Carson City, we respectfully ask you leave this area as it currently sits. Open space for all to enjoy.

Thank you.

Margie Quirk
Greg Hendricks

Pinion Hills Residents since 1994

Success is liking yourself, liking what you do, and liking how you do it.

Follow the link and LIKE please.

https://www.facebook.com/pages/Lone-Mountain-Veterinary-Hospital/325368242791

From: Virginia DaSilva
To: Stephanie Hicks
Cc: Madre DaSilva
Subject: Comment Sheet for BLM parcels in Pinion Hills Neighborhood
Date: Wednesday, August 30, 2017 11:24:54 AM

To Whom It May Concern:

First, thank-you for organizing last night's informational meeting. I thought the material was well-presented. I did listen to 3 persons in the audience make public comments, and then I left the meeting.
I also attended and commented at the previous meeting on this topic in July of 2016.

Our primary concern would be how the possible sale and development of the 14 parcels would affect the existing wells and septic systems. It would be helpful to know and understand more about the current source/sources of water in Pinion Hills. I am not sure where we would find that kind of information. Perhaps the USGS office could provide the neighborhood this information, as suggested by one resident.

Our secondary concern would be regarding the parcel directly to the west of our parcel though I am not sure what control the BLM and/or City would have with regard to the height/location of any future buildings on the parcel.
We currently have a lovely view from our home to the West.
If the purchaser were to build a residence and/or other buildings on the parcel, we can only hope our view is not blocked.

Sincerely,

Urbano and Virginia DaSilva
775-291-6994
owners of parcel # APN 10-082-13

August 29, 2017

Stephanie Hicks, Real Property Manager
Carson City Public Works
3505 Butti Way
Carson City, Nevada 89701

RE: Proposed sale of parcels in Pinion Hills owned by BLM

Dear Ms. Hicks:

I currently own and reside with my family on Parcel #010-094-06. My sister owns the parcel adjoining mine to the west, and my mother owns the parcel adjoining hers. My parents purchased all three parcels in 1965, and we have resided on this property throughout our lives, in my case since 1967. I also own a private access and utility easement through the parcels to access my property which I will never share with outside parties.

I strongly oppose the sale of any and all of the BLM parcels listed in your letter for a multitude of reasons. I understand the proposed purpose of these sales would be to grant the monies received from them to the Carson City Open Space Division to fund the creation of new open space. I suggest that this notion is ludicrous as it would destroy our existing natural open space to fund the same thing in a different location. The residents in our area, as well as the wildlife regularly utilize these existing open spaces and would be extremely adversely affected by their sales and development. Wild horses, deer and other wildlife regularly travel these corridors to access the river from the adjoining hills. The quality of life which the current property owners enjoy would be devastated by further development.

Of primary concern as the result of this proposal is the fact that this water basin is already grossly over allocated. This dire issue and liability can be substantiated by the numerous wells in the neighborhood which have failed and had to been deepened or dug in new locations. The depth of my well is over 360 feet, and at my mother's residence it is over 390 feet. If the additional parcels are sold and developed, it is probable that they may not be able to access enough water to support such development. Further, the development of new wells in this area would likely cause the failure of existing wells which would initiate a multitude of various problems and issues for the current property owners and the city alike. This issue alone should be enough of a liability to cause the city to reconsider the sales of these parcels and search for other means of funding their open space projects.

Another substantial concern is the intended means of lot access. Most of the proposed parcels do not currently have any means of access to them. The city would have to spend an excessive amount of money, not only creating new roads to access the parcels, but also to reconstruct all the roads in this entire area as the current condition of the roads is deplorable. In addition, proper drainage would need to be constructed on all roads, including new construction by the city, as this has not yet been completed on existing roads, despite the repeated requests of current property owners over the years. There are also a multitude of topographical problems which would need to be addressed as access would have to be constructed across drainage easements and cost prohibitive obstacles such as steep, sandy slopes and canyon walls. The city would have to bear all of these costs which it seems would prove to be more than devastating to any profit which is intended from the sales of the parcels. In at least several of the parcels, it is clear that retaining walls to support the access roads would need to be constructed to prevent their failure.

Additionally, throughout many of the proposed parcels, there are drainage easements and regular flooding and damage caused by drainage as the result of snow melt and heavy rainstorms. Drainage easements present problems with proposed development and may reduce the value of the parcels significantly.

If the parcels are sold, the current property owners in this area request that substantial bridle paths are constructed through all of the parcels for public equestrian use and foot traffic. Numerous residents in the area own and ride horses and train colts and other horses and will need to have access through these parcels which provide them safe passage, away from roads and residences which create safety hazards and liabilities such as barking dogs and motorcycle traffic.

Further development in this area would increase congestion and traffic considerably and devastate the quality of life for the current residents. In addition, fire protection would be a serious concern and the city may have to construct a fire sub station near the area to alleviate the threat of fire and public safety. The nearest fire station to our area is a thirteen minute response time from their location. The fire department would have to operate a water tender in response to a fire from downtown, while the rest of the city is supported by readily available fire hydrants. We have no fire hydrants in this area and the current condition of our neighborhood is not capable of supporting more construction and/or residents.

Finally, if the sale of the parcels is commenced despite all of the above concerns and liabilities, it is requested that the current property owners be granted first right of refusal for the purchase of the parcels adjoining their properties at a fair price.

Please feel free to contact me for further discussion of this matter.

Sincerely,

Jeanne Morgan
1677 Quail Lane
Carson City, Nevada 89701
775-691-6188
Jeannemorgan444@gmail.com

Deanna and Thomas Stilwell
1649 Quail Lane
Carson City, NV 89701
Phone: 541 875-2071
E-mail: tss@peak.org
August 23, 2017

Stephanie Hicks, Real Property Manager
Carson City Public Works
3505 Butti Way
Carson City, NV 89701

Re: Sale of 14 parcels owned by BLM throuth OPLMA, in Pinion Hills

Dear Ms. Hicks:

We have owned Parcel Number 010-094-03 in Pinion Hills since 1965. My daughter Jeanne Morgan, and her family, owns Parcel Number 010-094-06. My daughter Carolyn Aikins, and her family, owns Parcel Number 010-094-05. We all keep horses, dogs, cats and chickens. If the property around us is sold and developed, there is a strong concern close new neighbors might complain about our animals - noise, odor, etc.

A big concern is water. Our well is 393 feet deep with a limited supply of water. Development of all these new parcels would affect all of our wells and further limit the amount of available water - possibly causing our wells to fail. Many wells have been deepened over the years because of the water table deepening, including our well.

Crowded conditions with close neighbors would greatly increase the fire danger. We live in an area with lots of sagebrush and dry fuel. Already a neighbor caused a serious extensive brush fire a few years ago.

The two parcels that are situated directly south of Parcels 010-094-03, 010-094-05 and 010-094-06 are situated with their North edges in a drainage channel which runs strongly with water whenever it rains - like a flash flood - which erodes the ground. Those two parcels are mainly sand, and would be cost prohibitive to develop. Also, those two parcels are a main corridor for wildlife to access the river.

There is a 25 foot private access and public utility easement running to the North of Parcel 010-094-03 and Parcel 010-094-05, recorded as document No. 144539 in the Carson City Recorder's Office. This is a private access and under no circumstances will become a public access.

Would adjoining property owners have first right of refusal and priority in purchasing adjoining parcels to their own property to preserve their open space?

We strongly protest the new development of these 14 parcels and the crowding of our beautiful open environment on behalf of the people and animals who live here!

Sincerely,

Deanna M Stilwell

Deanna M. Stilwell

Thomas S. Stilwell

Thomas S. Stilwell

Janet L. Wills
1444 Pinion Hills Dr.
Carson City NV 89701

August 30, 2017

Stephanie Hicks
Real Property Manager
Carson City Public Works
3505 Butti Way, Carson City, NV 89701

Dear Stephanie

After attending last night's Open House, I want to share some comments and questions . as a 17 year resident of Pinion Hills, I am concerned by the BLM proposal to subdivide the 14 parcels of remaining BLM land in the PH subdivision into 1 acre parcels for sale.

*I am concerned about roadways/driveways needed to access the properties. (Dirt roads?) More dust, more congestion, to access the properties.
*I am concerned about 28 (more or less) new wells needed, in an area where many wells are already stressed.
*What about septic systems?
*Will the city require present residents to pay for installation and for city water service, and sewer service?
*Will we be required to hook up to natural gas service?
*If we must use city water service, will we be limited to household use only - as has been proposed in former "water saving" proposals? No good! Do I get rid of animals, trees,etc.?

My neighbors are among the most "water conscious" people I know, FAR better than the water-flowing gutters around the Capital and City/State offices. (And, why do they get beautiful green lawns, when we have become VERY xeriscape conscious ?)

I am concerned about a "checkerboard" neighborhood - 1 acre "city lots" mixed with 2.5 to 5 acre properties.

If the BLM must "sell off" these parcels, PLEASE require the parcels to remain their current size, without the option of subdividing.
PLEASE give adjoining property owners first option of purchase. (If regulations don't allow that, fix it!!)

Thank you for your efforts to explain plans for Pinion Hills. Just don't ruin our way of life in the process.

Sincerely yours,

Janet L. Wills

Janet Wills
janlouwills@gmail.com

From: prekbaum@aol.com
To: Stephanie Hicks
Subject: Pinion Hills
Date: Saturday, September 02, 2017 8:10:22 AM

I am a home owner at 1166 S Deer Run Rd, Carson City, and wanted to give you feedback on our well. We have lived here since 1992 and have had well work done a number of times. We have had to replace all the well pipes because of corrosion due to the heavy mineral content of the water. We had to deepen the well from 130 feet to 215 feet in Aug. 2013 after the town increased the water capacity of wells in Riverview Park. Last summer we had to replace our septic tank because the concrete disintegrated (leaving an open 2 foot diameter hole) due to the nature of the water. (It took the town two months to issue a permit for the replacement.) I am concerned that more wells in the neighborhood may lead to greater difficulties for the wells already established.
I also worry that more development would lead to more night light (street lights, spot lights...). I love our starry nights!
Thank you for hearing our concerns.

Paula & Vincent Baum
Sept. 2, 2017

From: Bob Heans
To: Stephanie Hicks
Subject: Re: Pinion Hills - BLM Parcels
Date: Thursday, September 07, 2017 5:21:37 PM

Thank you for emailing the powerpoint and fact sheet form the August 29, 2017, open house meeting.

We live at 1120 S. Deer Run Road, and our concern is it could effect the water table if all of the new owners of the parcels put in wells.

The wells in Pinion Hills neighborhood are all privately owned. Would the residents of Pinion Hills be compensated for the drop of the water level by drilling new wells for these parcels?

In the last year we have had to add pipe to our well because of water level. This is very costly to pull the pump and add pipe. Would this topic be presented to the Board of Supervisors?

Sincerely,

Janice A. Heans
parcel #010-082-17

On Fri, Sep 1, 2017 at 1:34 PM, Stephanie Hicks <SHicks@carson.org> wrote:

> Good afternoon:
>
> Attached as we discussed is the powerpoint from the open house as well as a fact sheet prepared to answer some of the questions we had received. If you have any comments or questions as you review, please do not hesitate to call me.
>
> Thank you,
>
> Stephanie Hicks, AICP, CFM

Real Property Manager

Carson City Public Works

3505 Butti Way

Carson City, NV 89701

(775) 283-7904

R. Brian & Lorna Coclich
1896 Quail Ln• Carson City, NV 89701• Phone: 775-882-9241
E-Mail: coclich@charter.net

September 12, 2017

Stephanie Hicks
& Carson City Board of Supervisors
Carson City, NV 89701

Dear Sir or Madam:

We are writing to voice our concerns over the proposed sale of BLM parcels in the Pinion Hills neighborhood. It is apparent that we, the residents, cannot stop this sale. However, as property owners that directly abut a proposed parcel of land that will be up for sale, we must object to the usage of closed competitive bidding to dispose of the lots. It would not only be a disappointment to the residents and homeowners of our neighborhood, but to the community as a whole, to allow a developer with deep pockets to come in and purchase the land for monetary gains alone. The message sent would be that current residents & landowners are not important to Carson City government. This issue is easily avoidable by giving first right of refusal to the adjacent property owner, then to an **OPEN** bidding process if first right is refused. Using the closed competitive bidding process all but guarantees that the local buyer will lose.

Those who choose to reside here do so to live in a rural area. Development of all parcels crushes that ideal. I can assure you that given first right, we would purchase the lot and keep it as open space; preserving the rural feel and way of life we want. Furthermore, sale to a current adjacent resident all but ensures that not every lot will be developed or have a new well installed. As you are aware, water is a large concern out here. Long-term impact studies have not been done to make certain that we have viable water reserves that can sustain the amount of growth that comes with the sale of these lots for development.

I am asking you, the Board of Supervisors, whom the citizens have elected, to represent and speak for your constituents. The appropriate decision by you is to not allow the closed or sealed competitive bidding process, which will send the message that your community is the priority. Inform the BLM that without open and fair purchasing options, you will not approve the sale of these parcels.

Sincerely,

R. Brian & Lorna Coclich

From: Stephanie Hicks
To: "Kirk and Charly Baron"
Subject: RE: Pinion Hills BLM property for disposal
Date: Monday, September 18, 2017 9:00:25 AM
Attachments: Chapter 12.15 Domestic Water Supply Systems.pdf
CCMC Div 16 Well Requirements and Specifications.pdf
CC Well Permit.pdf
CCMC Chapter 12.05.015 Individual Sewage Disposal System.pdf
CC Septic Permit.pdf

Good Morning,

Thank you for providing your comments on this matter. As requested, attached please find the Carson City permit application for well and septic, as well as the Carson City Municipal Code Sections.

If you have any further questions, please let me know.

Thank you,

From: Kirk and Charly Baron [redacted]
Sent: Saturday, September 16, 2017 9:31 PM
To: Stephanie Hicks
Cc: Bob Crowell; Karen Abowd; Brad Bonkowski; Lori Bagwell; jbarrette@carson.com
Subject: Pinion Hills BLM property for disposal

Stephanie,

My wife and I have lived in Pinion Hills for over 19 years. We attended the Open House, on 8/29/2017, concerning the proposal to dispose of 14 BLM properties in the Pinion Hills neighborhood. All of these properties are two or more acres and zoned SF1A so we could possibly see over 28 new homes in the area.

The main concern of the property owners attending the meeting is water. I know of four neighbors that have had to drill new wells or deepened existing wells with in the last year. My neighbor drilled a new well, just this year, to replace his original well that was not producing. They drilled the new well 60 feet away from our well and our water was muddy for a month. Four months later I replaced my pump, the water level had dropped since the last time I had our pump serviced.

Another question brought up was additional septic systems, how will they affect our water quality? Can you assure us that the possible 28 new wells and septic systems will not affect our water quality?

I would like a copy of the Carson City requirements for drilling new wells and installing septic systems. Please email a copy to kirkandcharly@gmail.com.

There will be increased traffic on existing roads in Pinion Hills; are the roads capable of handling increased traffic?

There no fire hydrants in Pinion Hill and the nearest fire station is over six miles away.

As the attached PowerPoint, that you distributed, shows; the same issue came up in 2006 and there were 13 meetings, in 2007 there were 2 meetings. We never received any notice of these meetings. We checked with neighbors living here at that time and they said they had not been notified either.

You stated that in 2009 the Board of Supervisors took no action to dispose of these properties. The BLM representative acknowledged that if the Board takes no action the properties will remain unsold. The Board could again take no action with no repercussions.

Why is there a rush to dispose of these properties? I encourage the City and BLM to work with the property owners in Pinion Hills to answer all of our questions. We need more meetings and they need to be at times when people are not at work. There has only been one meeting and it was called an "Open House". Calling this meeting an "Open House" seemed a bit deceiving, this was a meeting concerning the sale of a large portion of land in Pinion Hills, it seems like the City and BLM was trying to sugar coat an issue that is of great concern to properties owners in this area.

Thank you,

Kirk and Charlene Baron
1551 S. Deer Run Rd.
Carson City, NV 89701

From: hwilliams99@charter.net
To: Stephanie Hicks
Cc: "Jay.Moorhead.ctr@MSC.NAVY.MIL"
Subject: BLM parcels in Pinion Hills neighborhood
Date: Sunday, September 17, 2017 11:44:23 AM

Please pass on my comments to the supervisors.

My concern with the proposed sale of 14 two acre lots concerns water availability and quality.

Currently, Carson City does nothing to help Pinion Hills residents with any water issues, specifically access to water and maintaining the quality of the water. All residents in this neighborhood maintain their own wells and treatment systems to be able to use the water for drinking, bathing, and washing dishes and clothes.

The input from the city at the August 29, 2017 meeting was very limited concerning water. The only input that was shared was that the State said that water is not a concern. I would like a lot more detail on this statement to alleviate my concerns. Who specifically made this statement? Is it someone qualified to make such a statement? What exactly does this statement mean? What data is there to support this statement? Is there any contradictory data available?

I would also like to know what the city will do for us if our water supply is depleted. Lose of an adequate source of water for all property owners in this neighborhood would affect our property values and quality of life. Would the city be ready and able to fill the void? As you know, our property taxes are calculated the same as residents in town who do have access to water supplied, monitored and maintained by the city.

Increasing the number of users of the water supply through wells will decrease the supply for everyone. This includes new as well as established residences. Unless the city is certain that water will not be an issue or that the city is going to otherwise provide an adequate resource, they should not do anything to impact our water supply.

Elizabeth Williams
2049 Pinion Hills Dr.
Carson City, NV

September 15, 2017

Stephanie Hicks, Real Property Manager
Carson City Public Works
3505 Butti Way
Carson City, Nevada 89701

RE: Comments/Questions regarding Pinion Hills parcels

Dear Ms. Hicks,

Thank you so much for affording us the opportunity to submit comments and questions to you regarding the proposed sale of the Pinion Hills BLM parcels.

My primary request regarding these parcels is that the City makes the decision to Stay all sales of the parcels at this time and utilize them for wildland and open space as they have always been. All the residents in this community utilize the parcels on a regular basis and would very much appreciate the continued use of them as open space. I know you prioritize the maintenance of open space in our community and this is a perfect opportunity to have more at no cost to the City or taxpayers.

If the City wishes to proceed with the sales of the parcels, we would request that the sales be stayed long enough to allow the current land owners in the area to request a change in Federal legislation to allow the current residents first right of refusal in the purchase of adjoining parcels to their properties. This is a fair request and would be of no detriment to the City in any way.

Of primary concern to myself as well as all other residents in this community is the lack of enough water to support more development in the area. As you are now aware, the lack of and poor quality of water has been an ongoing problem in this area and our community would ask the City where the excess water will come from if you sell the proposed parcels. It is requested that professional studies by qualified individuals be conducted regarding the water issues in the area to afford adequate and accurate answers to these questions, and to prevent future legal issues due to water failures. It is requested that results from these studies be provided to the current residents for review as they are completed.

Of additional concern to our community is the lack of access to most of the proposed parcels. In addition, it is noted that the current condition of the roads in the entire community are deplorable and drainage management is almost non existent. If the City sells the listed parcels for development, there could be a minimum of an additional 110 residents in the neighborhood. It is requested that a professional study be conducted at the direction and cost of the City to determine the impact on the huge increase in traffic in the area as a result of such development. In addition, we request that if the City sells the parcels, all roads in the community be reconstructed properly and proper drainage in all areas installed. The City will also be compelled by development of these parcels to construct new roads, drainage, appropriate bridges and retaining walls to allow access to all of the parcels as proposed by the City. It is asked that a study be conducted to determine whether some of the parcels are even buildable or if it would be cost prohibitive to sell them as buildable properties due to the problems in topography and excavation, etc. It is also asked that the results of these studies be provided to current residents in the community for review.

It is very concerning that the City proposes to allow additional development on this scale in a community with such a marked lack of infrastructure. Fire protection is also of primary concern. There are no fire departments near the area, nor are there fire hydrants. In addition, the ability of emergency medical personnel to respond to emergencies in this area is deficient and would need to be addressed with the addition of such a large number of residents in the area.

As mentioned in my previous letter, if the City decides to sell the parcels for development, it is requested that equestrian access be provided through the parcels for safe passage by residents at the direction and cost of the City as has been requested and provided in other similar developed areas.

It is requested that a cost study be conducted by the City to determine the cost of reconstruction of roads and drainage, construction of new roads, water studies, fire protection and emergency medical personnel additional infrastructure, and all other costs which the city will incur if the parcels are sold for development. It is likely that the sales of the parcels would not justify the cost of the infrastructure the City would need to provide to support the development proposed. Perhaps the monies for open space can be otherwise acquired and the current open space in this area can be maintained as such by the City. A decision to do so would be greatly appreciated by the residents and landowners in the area and can be represented to the community as a great acquirement by the City at no cost to the taxpayers.

Please keep us updated as to the City's decisions and actions regarding the proposed sales of the parcels. This proposed action will have an enormous impact upon all the residents of this community and it is appreciated very much that you include us in your decisions. Thank you so much for your time and consideration.

Jeanne Morgan
1677 Quail Lane
Carson City, Nevada 89701
775-691-6188

Thomas and Deanna Stilwell
1649 Quail Lane
Carson City, NV 89701
E-mail: tss@peak.org
September 17, 2017

Stephanie Hicks, Real Property Manager
Carson City Public Works
3505 Butti Way
Carson City, Nevada 89701

Re: Comments/Questions re Pinion Hills parcels

Dear Ms. Hicks:

As we said in our first letter to you of August 23, 2017, we have owned and lived on tax parcel 010-094-03 (1649 Quail Lane, Carson City, Nevada 89701) since 1965.

We are very much opposed to the sale of additional parcels in Pinion Hills, primarily because of the availability of water to supply new homes. Our well is very deep - 393 feet - has a limited supply of water, and if more wells were drilled in Pinion Hills, it might cause the existing wells to fail. We had to deepen our well several years ago to ensure an adequate supply.

Also of major concern is access to these parcels that are proposed to be sold. The south side of our parcel and my daughter Carolyn Aikins' parcel (tax parcel #010-094-05), and my daughter Jeanne Morgan's parcel (tax parcel #010-094-06) is a flash flood drainage ditch when it rains. This is supposed to be a road easement if those two adjacent 2 1/2 acre parcels are sold and developed. Also, that steep hillside where those two parcels are located is very sandy - not a good foundation for housing development.

The fire danger would increase with more development in the area. A major brush fire started behind our neighbor a few years ago.

Studies would have to be done regarding availability of water, construction of roads, management of storm water drainage, fire protection - and the cost to Carson City of these studies and road construction and flood control if these new parcels are sold. We request that these studies, and any other information regarding the sale of these parcels be made available to us by e-mail:

E-mail: tss@peak.org

or by mail:

1649 Quail Lane
Carson City, NV 89701

and to the other property owners in the Pinion Hills community.

We have very much enjoyed our open spaces for the past 52 years - riding our horses, hiking, observing the wildlife, and just living in the country. Crowding the community would destroy these open spaces and prevent wildlife's free access to the river. We hope Carson City decides not to sell these parcels and retains them for open space and wildland as they have been since we have lived here since 1965.

Thank you for involving us - the existing residents of Pinion Hills - to be a part of the decision to sell these parcels.

Sincerely,

Deanna M Stilwell
Deanna M. Stilwell

Thomas S. Stilwell
Thomas S. Stilwell

Date: September 18, 2017

To: Stephanie Hicks, Real Property Manager, Carson City Public Works

From: Rob Scanland, Property Owner 1300 Pinion Hills Dr., Carson City

Subject: Comments on proposed Pinion Hills Neighborhood Land Sale

- It seems ironic to be selling undeveloped rural lands, currently providing open space and wildlife habitat to fund acquisition of other “environmentally sensitive land” for open space and wildlife habitat.
- The Pinion Hills neighborhood is rural in character and was defined by its limited private land base. This sale will change that land base, by selling public lands, and change some of the very nature of why most of us chose to buy in this area.
- The sale and development of the proposed lands with 14 to 28 new wells will negatively impact our local aquifer, on which each of us depend for our water source.
- The sale and development of the proposed lands with 14 to 28 new septic systems will negatively impact our aquifer and our only water source.
- The sale and proposed development will further congest the neighborhood, increase traffic volume in an area with narrow and poorly maintained roads.
- The sale and development is strongly opposed by the neighborhood as evidenced by the turn out and opposition to the sale at the August 29, 2017 Open House.
- To minimize the numerous adverse impacts stated above the Board of Supervisors should NOT request the sale of these lands
- At the very least, if a sale were to proceed, the zoning should be changed to prevent any further subdivision of the roughly 2 acre lots, to help reduce the substantial impacts that current property owners will face if the sale of these lands proceeds.
- If the sale were to proceed, adjacent property owners should be given, the first right to pay appraised value, prior to a field bid auction. This would also help reduce the numerous adverse impacts this sale effort will produce.

Thank you for the opportunity to provide public comment and voice opposition to the sale of BLM lands in the Pinion Hills neighborhood.

Al and Carolyn Aikins
1663 Quail Lane
Carson City, NV 89701
Phone: 775 230 9146
carolyn.aikins@yahoo.com
Sept 16, 2017

Stephanie Hicks, Real Property Manager
Carson City Public Works
3505 Butti Way
Carson City, NV 89701

Re: Sale of 14 parcels owned by BLM through OPLMA, in Pinion Hills

Dear Mrs. Hicks:

I was born in Carson City in 1969. I was raised at 1649 Quail Lane, parcel number 010-094-03 with my parents and two sisters. My parents sold my sister and I each a parcel in 1993 and 1997. Jeanne Morgan owns 010-094-06 and mine is 010-094-05. We strongly protest the development of BLM land through the Omnibus Public Land Management Act of 2009.

A major concern is water. Our well is currently 369 feet deep. We have to be very careful with water usage. Our water pressure is very poor and has to be "rested" in between uses due to minimal pressure and brown water. The drilling of several additional wells would be detrimental to the existing wells in this area and will further limit water usage: possibly drying them up completely. The deepening of the water table is a real problem and many residents are continually forced to pay to have their wells deepened. My uncle moved to Dayton due to his well drying up. Continual problems with water quality and availability are ongoing concerns . This is a common problem as it is not uncommon to see well drilling equipment in the area.

In addition to the water table decreasing, it is important to mention how poor the water quality is. Lab tests reflect myriad pollutants indicating that the water is not safe to drink. In addition, many of the residents have hydrothermal wells. We have to use a water softener and reverse osmosis system. Still, the hard water stains appliances and eats through faucets and pipes continually requiring maintenance and replacement.

Another concern is that many parcels are situated in drainage channels which become flash flood zones when it rains. These parcels consist predominately of deep sand and are sloped causing a significant amount of erosion. In order to make these properties buildable it would be cost prohibitive for buyers.

Further, the area has a lot of pinion pine, juniper trees, sagebrush, and dried grass which helps hold the soil. Crowded conditions would further increase fire danger and endanger wildlife and residents as well as increase the funding needed to fight fires.

The roads in the area are very poorly maintained. At the very least the city needs to really examine what the cost would be to improve the infrastructure, build and maintain roads as well as improve existing roads which are in very unacceptable conditions.

This area is currently a beautiful open environment. It is a unique recreational area which many residents currently enjoy. Pinion Hills is home to wildlife, hikers, equestrians and residents who strongly protest new development Please consider our concerns and the demise of our quality of life.

Thank you for your consideration:

Albert and Carolyn Aikins

Carolyn Aikins

al Aikins

September 19, 2017

Stephanie Hicks, Real Property Manager
Carson City Public Works
3505 Butti Way
Carson City, Nevada 89701

RE: Pinion Hills parcel Comments & Questions

Dear Ms. Hicks,

Thank you for the opportunity to provide input concerning the proposed transfer and sale of BLM Pinion Hills parcels. Our property at 6051 Pursia Road (built in 1968) is surrounded by the proposed parcel sales. We appear to have some of the most significant impact as it relates to density increase surrounding our property.

Of major concern to us and relayed by our neighbors in the introduction meeting with your team is the potential impact to water. As noted in that meeting, the aquifer within the area provides hot water to almost all the homes and has proven to be of very poor quality. As housing is added to the area with increased demand on the limited supply, we have seen negative impacts to our well water output. Our well had to be deepened approximately 10 years ago due to water table drop and silting. This occurred after 5 new homes had been built with 4 having a very near proximity to our property and 1 home adjacent to. We fear that this expansion will have a similar impact with even more impact with the number of new septic systems which might be approved above our well.

We have great concern that our historical use of the water will be taken from us or we will be damaged from over development of water use and will face a lack of useable water or extensive cost for well replacement. We suggest an extensive study be done to review the aquifer impact and capacity as it relates to this projected demand and that this study be shared with all the home owners affected by this proposal.

Even though the areas reside outside of flood plains, it should be noted that the slope and drainage from the Pine Nut Mountains has resulted in significant sheet erosion during wet years. With removal of vegetation for development above our property, we would need the developer and city to stipulate significant mitigation to reduce this erosion risk. Current measures are in place on my property and with an adjacent neighbor to currently help control these peak flows. We would expect this impact and cost for mitigation to be included in the overall review and report to the Supervisors

Infrastructure supporting added development would require significant investment to establish flood control which is nearly nonexistent within the area access roads. Currently water on Pursia Road runs down to Deer Run and creates a pond of water adjacent to the road. As more homes are added and vegetation removed this water flow and ponding would increase and eventually cover the road and create a safety hazard. We have long response times for fire and emergency which will need to be addressed if more demand is expected with higher density development.

The area has significant open space use with OHV staging areas currently in use on some parcels. These areas use Sedge Road and the Powerline for additional access into the Pine Nut mountains. Many use the area for horseback riding and mountain biking access. The area is currently used as recreation open space by the neighborhood and by many Carson City and outlying area residents.

Selling off open space that currently gets high use by OHV riders make little sense. Can you imagine living next to that use, dust, noise and exposure to the 120KV power line. Are these really desirable sites for housing development. Will the restriction of recreation be the next step with results similar to what took place with the adjacent developments to Prison Hill.

I encourage the review team and the Board of Supervisors to take all these issues into consideration and to weigh the cost for infrastructure that will be needed and risk of neighborhood damage and open space loss that the city takes in developing these parcels.

We encourage you to list open space as your preferred alternative since it has significant use already and adds to the quality of life in Carson City. This also provides the lowest risk to the city related to damage resulting from negative impact to water and cost for added infrastructure.

As a low density/open space alternative, adjacent property owners could be given a right of first refusal and select parcels could be maintained as open space. Additional restrictions could be added to reduce the density and demand on water and infrastructure by restricting parcel sub-division. These restrictions could be reviewed at a later time with infrastructure and water access improvements that mitigate risk.

Thank you for your consideration in reviewing these comments.

Sincerely,

Greg Hendricks
Margie Quick
6051 Pursia Road
Carson City, Nevada 89701
775-883-4584 home
775-315-6464 Cell for gh

MAHE LAW, LTD.
707 North Minnesota Street, Suite D, Carson City, NV 89703

September 18, 2017

Stephanie A. Hicks,
Carson City Real Property Manager
3505 Butti Way
Carson City, NV 89701
Via Hand Delivery

Re: Sale of Real Property in Pinion Hills

Dear Ms. Hicks:

Please be advised that this office has been retained by Kirby Nish, a resident of the Pinion Hills neighborhood, to address the proposed sale of real property currently owned by the Bureau of Land Management ("BLM") in the Pinon Hills neighborhood. Pursuant to my client's request, please find enclosed his correspondence regarding the issue along with a Power Point presentation he prepared on the topic. As you will note, Mr. Nish is adamantly opposed to the proposed course of action for a variety of reasons.

One such ground for Mr. Nish's opposition is the fact that any further development in that area would likely have an adverse impact on the water quantity and quality in Pinion Hills. As you have been advised, all residents in the Pinion Hills neighborhood are reliant upon domestic wells as their source for water, and numerous issues regarding the quantity of available water as well as the quality of the water which is pumped from the domestic wells have been encountered. For example, Mr. Nish has been advised that at least one residence has been rendered uninhabitable as a result of the inability to obtain water for that residence. Additionally, Mr. Nish has personally encountered issues with a lack of water pressure and available water as well as issues with the potability of the water which he pumps from his personal well. Specifically, Mr. Nish has had his water tested and though he has been advised that it is technically potable the test results indicated that he should not drink the water. Obviously, should Carson City approve the proposed sale of real property it will be exposing the current residents of Pinion Hills to health and safety concerns related to the impacts upon their existing water sources. Additionally, the City will be allowing potential purchasers to invest in the newly available property despite the fact that they may be unable to drill wells that can be permited by the City pursuant to Carson City Code Section 16.1 as well as increasing the likelihood that the City will find it necessary to invest in additional infrastructure to provide City water services to the Pinion Hills neighborhood if domestic wells are no longer able to provide potable water to those residents.

As has been recognized by the Nevada Supreme Court "[w]ater in Nevada … is a precious and increasingly scarce resource." Bacher v. Office of the State Engineer, State of Nevada, 146

P.3d 793, 797 (2006). Moreover, the Nevada Legislature has declared it the policy of the state to protect domestic wells and their supply of water from municipal uses. NRS 533.024(1)(b). Arguably in this case, should the City decide to approve this action so that it may acquire funding to use for other projects at the expense of the owners of domestic wells in Pinion Hills, such a use by the City would violate the declared policy stated in NRS 533.024(1)(b). Finally, the City must consider the likelihood that this proposed sale will be unable to move forward as a result of the analysis required pursuant to the National Environmental Policy Act ("NEPA") which will consider, among other things, the detrimental impacts to the water quantity and water quality.

As a result of these concerns, it is Mr. Nish's position that a more responsible choice by the City would be to identify properties for sale outside of Pinion Hills that do not involve these complicated issues. Pinion Hills residents purchased their properties having expectations of the continued rural character of the neighborhood which we would like to see protected and are greatly concerned that rampant development would be inconsistent with the historical pattern of slow growth over time and balanced use which includes recreational, open space and conservation.

Sincerely,

JENNIFER MAHE

Encls.

Cc: Client
Carson City Board of Supervisors via Nick Marano, City Manager (Via Hand Delivery)

To: CC Planning Commission/Board of Supervisors
From:
Kirby Nish-Homeowner
(775) 882-8951/297-5726

Background:
I am a Carson City resident of 45 years. My home in Pinion Hills was purchased for its rural character a function of city parcels being inter-twined with BLM land. This created a good quality of life for the residents. It afforded the BLM the opportunity to have livable areas at the east end of Carson City as a buffer against wildlife (horses, coyotes, rattlesnakes, and an occasional mountain lion).

With the Federal Lands Act (year) and recent Omnibus Land Act, the city/State seek to "sell-off" BLM fourteen (14) parcels with the notion that it will generate increased revenue base. It also assumes that the residents will be supportive.

For years, the BLM's posture has been one of conservative and responsible stewardship of these lands. Parcels were marked for alternative uses, not only for residences, but also for open space, recreation and enjoyment by the public at large. It is in this multiple use interest that their posture with respect to usage and change has been in the best interests of the community and State. It never lost site of the open space, recreational and character of our neighborhood.

Now the City/State seek to dispose of parcels through sale. This would be an exclusive focus on development with the sole perspective of revenue.

However this would be an egregious **MISTAKE**!

This course of action seeks to abrogate a over a century's' posture of Nevada being characterized by its open spaces growth defined as slow and over time. It is the overarching reason why people and business find Nevada attractive. Unlike California, its rural character differentiates it from the rampant growth and urbanization as a given.

Adverse Infrastructure Repercussions

Impact Fees:

Typically, the sale of blocks of land is made to investors with the financial wherewithal to move forward and sustain development. Specifically, the costs to a polity of development fees are passed along to the developer a function of the tenet of efficiency. A city/State does not want to absorb these heavy sunk costs that are by definition exceedingly expensive for its infrastructure to support. This includes all pre-development costs related to the land conforming to like-and-kind residences. Topography comes into play. Commonly a given for development is a flat parcel with no developmental issues with respect to build-ability as it relates to the land itself. Not only are parcels in Pinion Hills largely on not flat or "hilly" terrain, there is a questions with respect to the underlying land.

As example, the Ambrose Park area about 20 years ago was examined by the City for residential development. This was abandoned because the underlying soil was sandy, lacking integrity and too near the Carson River such that future "sinking" or shifting in the land could occur.

There is an existing problem in Pinion Hills for lack of a sewer infrastructure. Unlike "the downtown" streets, there are effectively no sewers. Despite an assessment being paid by homeowners for sewers, this is a taking in that the homeowner currently receives no benefit, as there are no sewers. Residents are paying for sewers that are "on paper," but do not exist. The city maintains that this assessment is for future development. However, realistically the capital development being paid for exclusively by homeowners is ludicrous. Sewers in Pinion Hills will by definition be quite costly but necessary if the area is "fully built-up." Carson City will end up paying for the cost of this development.

No single or small group of investors will buy these parcels. They will be sold piecemeal as two-acre parcels and likely sub-divided into one-acre parcels by the brokers/realtors who list them. This will negate the possibility of Carson City recouping impact fees for sewer.

The same quantum capital outpour by the city will similarly be realized with respect to water. There are no city wells that serve Pinion Hills. Homeowners are left to drill/maintain private wells that are questionable at best. Almost all (save several homes) in Pinion Hills have HOT WATER! It comes from the ground at a temperature that is so high, that it is a per se requirement that homeowners install cooling tanks. These cooling tanks are sometimes fitted with costly systems to help cool the water.

In addition, the water commonly from the ground is Pinion Hills in non-drinkable. Though it may be technically potable, lab tests reflect myriad pollutants (arsenic, rust, sulfur, mercury, etc.). This means that the water is not healthful to drink. From first lab report years ago, I have cessated my consumption of the well water as being parlous (over time) and have to import bottled water. This is a liability issue for the City. Does it want to encourage more development given the water in the area is suspect? Is it prepared to expend the huge capital outlay necessary for the installation of city wells and filtering?

Already, the EPA with respect to the community wells in Carson City's' downtown has raised issues. They have said that Carson City is out of compliance with respect to the its quality of water from its existing wells. This has resulted in federal mandates to "clean up our water." It is a costly proposition that the city/State continues to address. Why would Carson City want to promote the sale of parcels in an area with "chump change" return (property tax revenue) (thousands) against the capital investment (millions). Even if treated, especially if not is the city prepared to face exponential liability/remediation costs? So monies (millions) will need to be spent installing city wells with no release of liability exposure. If the city fails to install these wells-encouraging domestic (unfiltered) private wells-its responsiblity fo the bad water is has no limit! East side citywells\sewers are cost prohibitive!!!

A person purchasing a parcel is at a disadvantage developing a lot in Pinion Hills. Unlike many wells that are shallow (i.e., 40-60 feet) commonly Pinion Hills parcels-predominantly on steep sloping streets need to "drill down" much further to get water. My personal well has been drilled/deepened several times and is currently 275 feet deep (verifiable by McKay Well Drilling). In addition, the well is costly to maintain. Every few years, a pump/drilling business has to service the well. This is not a mere housekeeping expense but quite costly. The replacement of a pump commonly entails the replacement of the piping (galvanized/pvc) and wiring. Moreover, commonly the well has to be cleaned out or "flushed." This can easily translate to an unexpected cost to a homeowner (i.e., $12,000-$14000).

This cost is added to if more drilling is necessary. Recently, I had a colloquy with my neighbor Wayne Campos. His house sits near the base of Pursia Road and at the bottom of my hill. Even though he is situated about 200 feet lower than my home, he has to drill deeply for water. Recently having moved from his home, he was not living there nor renting it. It was vacant. I asked him why. He replied-"No water." He conveyed that his well had run dry and he was compelled to move.

I have seen numerous well-drilling "rigs" in our neighborhood and know as a fact that homeowners in our residential area are sharing his and my plight.

<u>The existing aquifer in Pinion Hills is essentially dry</u>! With my well, it is <u>almost dry</u>. This is despite numerous well company responses and costly efforts. I run out of water such that I cannot even hand water shrubs with a common garden hose. The volume/pressure of the water declines to a mere trickle. I am forced to wait many hours until the well "recharges" (the aquifer gradually fills with water) to shower, bathe and make even the most Spartan attempts at getting water. <u>Pinion Hills has rust-colored and hot water</u>.

If Carson City moves forward with the disposal/sale of these parcels, then it must be ready to install city sewers and community wells. This will entail millions of dollars. As impact fees will not be paid by developers, the lots being sold "one by one," private parties will not be the "deep pockets" that city would need to recoup even a fraction of this exhaustive capital outlay. Even if the cost of sewers/community wells was passed on to homeowners via improvement bonds, the bonds could not even partially, absorb these overarching costs. It would result in property taxes for this area escalating with homeowners upset as result.

In comparison to these extreme "sunk costs" of Carson City funding this new capital infrastructure on its East Side, the resultant liability exposure is exponential. As seen recently in Flint Michigan, the liability exposure resulted in actual liability to the polity (city/State) to the tune of hundreds of millions of dollars. The problem there was so remarkable and manifest that it made national news, elicited a federal response and EPA and other regulatory agency response.

Are you willing Carson City to tell a child that the drinking water from a new private well is safe for him to drink? Are you willing to, as polity, absorb or underwrite this liability? Are you prepared to immediately begin concomitant development on sewers and the most modern (filtered) community wells to support this new growth?

Will the paltry property tax cash flow increase even begin to cover these developmental/liability costs? Are you willing to fund this "out of pocket" as a city in recognition that there will be no impact fees or any single developer accountable?

In summary the Planning Commission seeks to move forward with development that residenrs do not want!

In its closed minset, it ignores alternatives to development:

- Open space
- Conservation
- Recreation

It wrongfully assumes more revenue, but will only generate ill-affordable cost prohibitive fees.

The cost of new infrastructure will be in the tens of millions of dollars. If sewers\city wells are not installed, its non-divestible liability skyrockets!

Leave Pinion HollsEast alone Carson City! The residents and community-at-large don't want it! They prefer open space, conservation and recation. Follow the good stewardship of the BLM over the past 80 years! Leave our neighborhood alone!

Sincerely,

Kirby Nish

Pinion Hills Residents' Opposition to Sale of BLM Parcel Presentation

By

-Kirby Nish

& Fellow Homeowners Adversely Impacted

Carson City Planning Commission Meeting-August 29, 2107 (Ts.)

Carson City Community Center
851 E. Williams Street
Carson City, NV 89701

7:30 P.M.

-Pursuant to the letter mailed by CC Planning Commission- Stephanie A. Hicks

-August 8, 2017

-City's intention to dispose (sell) fourteen (14) parcels in Pinion Hills

CARSON CITY NEVADA
Consolidated Municipality and State Capital
PUBLIC WORKS

August 18, 2017

Dear Property Owner,

Within the Pinion Hills neighborhood, 14 parcels currently owned by the Bureau of Land Management have been identified for sale through the Omnibus Public Land Management Act of 2009 (OPLMA). The parcels are highlighted on the attached map and are listed below by Assessor's Parcel Number:

Pinion Hills

APN 010-082-04	Zoning: SF1A	APN 010-083-06	Zoning: SF1A
APN 010-084-03	Zoning: SF1A	APN 010-084-02	Zoning: SF1A
APN 010-087-05	Zoning: SF1A	APN 010-087-06	Zoning: SF1A
APN 010-087-07	Zoning: SF1A	APN 010-087-08	Zoning: SF1A
APN 010-093-03	Zoning: SF1A	APN 010-094-02	Zoning: SF1A
APN 010-093-05	Zoning: SF1A	APN 010-097-02	Zoning: SF1A
APN 010-098-01	Zoning: SF1A	APN 010-098-02	Zoning: SF1A

Primary allowed uses in the SF1A (Single-family 1 acre) zoning include a single-family dwelling and park. Accessory uses include accessory farm structures, accessory structure, agricultural use, animals and fowl, guest building, home occupation and individual or subdivision recreation use (swimming pool, tennis court).

Carson City is interested in your feedback regarding the sale of these parcels. You are invited to an open house to discuss the sale of BLM parcels in the Pinion Hills neighborhood. The meeting will include a brief presentation on the parcel locations and the sale process, followed by an opportunity to ask questions.

The open house will be held on Tuesday, August 29, 2017 starting at 5:30 pm at the Community Center, Sierra Room, 851 East Williams Street, Carson City, Nevada 89701. Your input would be greatly appreciated!

If you are unable to attend, please submit comments to:

Stephanie Hicks, Real Property Manager
Carson City Public Works
3505 Butti Way, Carson City, NV 89701
or email to shicks@carson.org

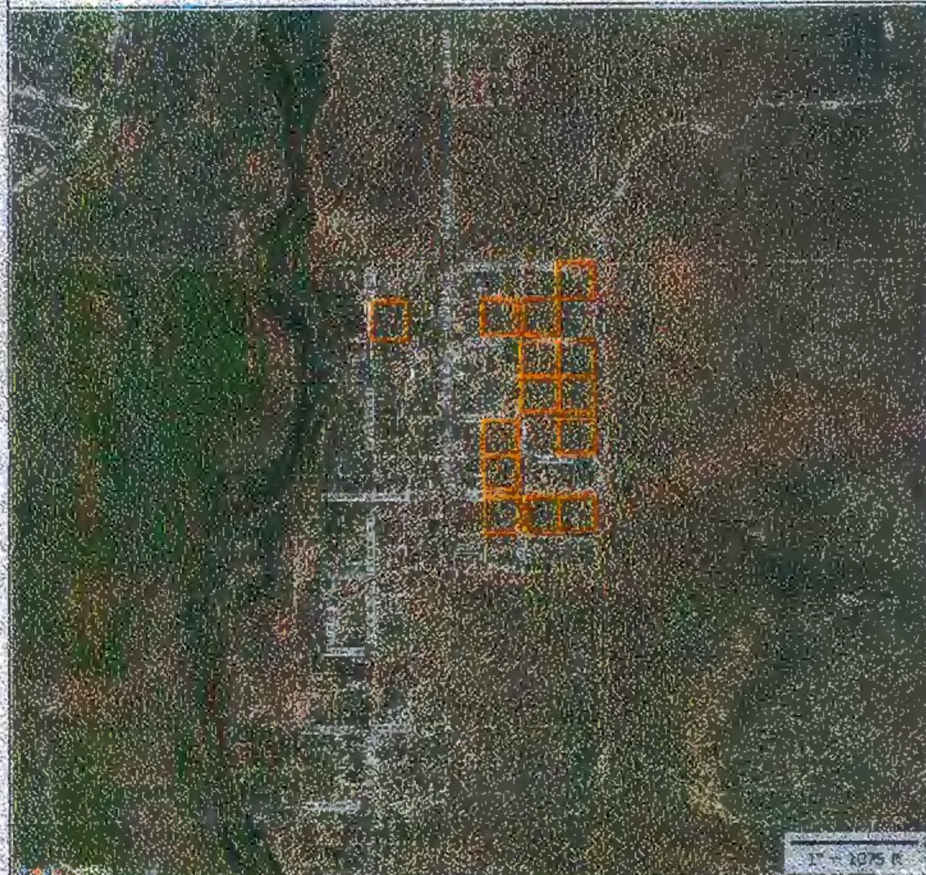
Please feel free to contact me directly at (775) 283-7904 for additional information.

Sincerely,

Stephanie A Hicks

Stephanie A. Hicks, AICP, CFM
Real Property Manager

BLM Properties for Disposal



Property ID

Owner BLM

MAP FOR REFERENCE ONLY
NOT A LEGAL DOCUMENT

Carson City, NV makes no claims and no warranties, expressed or implied, concerning the validity or accuracy of the GIS data presented on this map.

Pinion Hills Residents' Opposition to Sale of BLM Parcel Presentation

Addressing the external environment of Carson City

[redacted]

to Carson City Government

A Resident of Pinion Hills for 45 Years!

- I am a Carson City resident of 45 years. My home in Pinion Hills was purchased for its rural character a function of city parcels being inter-twined with BLM land. This created a good quality of life for the residents. It afforded the BLM the opportunity to have livable areas at the east end of Carson City as a buffer against wildlife (horses, coyotes, rattlesnakes, and an occasional mountain lion).

Pinion Hills Residents' Opposition to Sale of BLM Parcel Presentation

The proposed sale of BLM parcel would ruin the quality of life in the neighborhood.

It would be an overnight transmogrification

(sweeping change) from rural to urban.

Reorganizing the "Key Players"- Stakeholders- with Respect to BLM Parcels

- Homeowners who purchased for the rural character of the neighborhood
- Citizens of Carson City who prioritize open space/recreation and conservatory use of the land
- The Planning Commission-who ignores externalities with a "build only" proposition
- The City Supervisors who can see the huge capital costs and liability exposure and prevent the raping of our neighborhood
- Federal Regulators (EPA) etc. who will hold CC responsible for irresponsible development

The BLM Has Been a Good Steward of the Land

- For years, the BLM's posture has been one of conservative and responsible stewardship of these lands. Parcels were marked for alternative uses, not only for residences, but also for open space, recreation and enjoyment by the public at large. It is in this multiple use interest that their posture with respect to usage and change has been in the best interests of the community and State. It never lost site of the open space, recreational and character of our neighborhood.

BLM Has Been a Proponent of Balanced Use and No Growth

Parcels have been considered for multiple uses:

- Conservation
- Open Space
- Recreation

Only fairly recently have parcels been marked for "disposal" (sale)

Existing Residents Purchased Their Homes with Expectation of a Rural Quality of Life

- Citizens routinely enjoy the open space rural character of the land
- The rampant overnight development being proposed by the Planning Commission is reckless
- It is a Draconian "sell-off" of parcels for express development
- It ignores the best interests of the homeowners and the community

Carson City Residents Prefer Open Space, Conservation and Recreational Use

- The Planning Commissions' proposal seeks to abrogate a over a century's' posture of Nevada being characterized by its open spaces growth defined as slow and over time. It is the overarching reason why people and business find Nevada attractive. Unlike California, its rural character differentiates it from the rampant growth and urbanization as a given.

Carson City Residents Prioritize Non-Development

Citizens routinely enjoy the open space rural character of the land:

- Hiking
- Horseback riding
- ATV usage
- 4-Wheeling

The Carson City Planning Commission is Errantly Looking at one Exclusive Focus-The Sale of These Parcels

It must consider all the potential uses of the land-not merely development:

- Conservation
- Open Space
- Recreation

In Contrast, The Planning Commission is Acting in Reckless Abandon

- Now the City/State seek to dispose of parcels through sale. This would be an exclusive focus on development with the sole perspective of revenue.
- However this would be an egregious **MISTAKE**!

The Carson City Planning Commission has Acted Capriciously and in Bad Faith

- It has ignored alternative uses of the land:
- Open Space
- Conservation'
- Recreation
- It has conducted "closed doors" activities to keep this matter "hush, hush"
- It has failed to disseminate its actions to the media (newspapers, television, radio channels)
- Its letter has been a "quiet mailing" designed to attract little attention and to promote a "done deal"
- This smacks of bad faith and opportunistic behavior

CC Planning Commission Flawed Assumptions

- With the Federal Lands Act (year) and recent Omnibus Land Act, the city/State seek to "sell-off" BLM fourteen (14) parcels with the notion that it will generate increased revenue base. It also assumes that the residents will be supportive.
- It assumes a “no cost” or “low cost” to Carson City which is NOT VALID

Pinion Hills Lacks a Sewer Infrastructure

- Unlike "the downtown" streets, there are effectively no sewers.
- Despite an assessment being paid by homeowners for sewers, this is a taking in that the homeowner currently receives no benefit, as there are no sewers. Residents are paying for sewers that are "on paper," but do not exist.

Sewers For Pinion Hills Will Be A Must Given New Development

- The city maintains that this assessment is for future development.
- However, realistically the capital development being paid for exclusively by homeowners is ludicrous.
- Sewers in Pinion Hills will by definition be quite costly but necessary if the area is "fully built-up."
- Carson City will end up paying for the cost of this development.

Don't Expect the Residents to be Able to Pay

- Even if amortized over increased property taxes, or a long term (I.e., 30 year bond), the cost of new sewers and community wells will be in the milions
- Therefore the ultimate cost will be borne by CARSON CITY
- Impact fees will not be assessable to the developer because there is no single one…parcels will be sold "willy nilly" and the entire community will have to "foot the bill" for sewers/community wells

Get Ready to Pay for New Sewers on the East Side Carson City!

- Runoff down the east sides' hilly roads is a documented and costly reality given we have no sewers
- No single or small group of investors will buy these parcels. They will be sold piecemeal as two-acre parcels and likely sub-divided into one-acre parcels by the brokers/realtors who list them.
- This will negate the possibility of Carson City recouping impact fees for sewer.

Aquifer in Pinion Hills is Inadequate! No water!!!

- This cost to buyers of a well is added to if more drilling is necessary. Recently, I had a colloquy with my neighbor Wayne Campos. His house sits near the base of Pursia Road and at the bottom of my hill. Even though he is situated about 200 feet lower than my home, he has to drill deeply for water. Recently having moved from his home, he was not living there nor renting it. It was vacant. I asked him why. He replied-"No water." He conveyed that his well had run dry and he was compelled to move.
- How many lawsuits will CC see after selling parcels with inadequate/poor water?!!!

Inadequate Water in Pinion Hills to Sustain Daily Activities!!

- The existing aquifer in Pinion Hills is essentially dry! With my well, it is almost dry. This is despite numerous well company responses and costly efforts. I run out of water such that I cannot even hand water shrubs with a common garden hose. The volume/pressure of the water declines to a mere trickle. I am forced to wait many hours until the well "recharges" (the aquifer gradually fills with water) to shower, bathe and make even the most Spartan attempts at getting water.
- I have seen numerous well-drilling "rigs" in our neighborhood and know as a fact that homeowners in our residential area are sharing his and my plight.

Hot Water from Domestic Wells Means Expensive Community Wells!

- There are no city wells that serve Pinion Hills.
- The same quantum capital outpour by the city will similarly be realized with respect to water.
- Homeowners are left to drill/maintain private wells that are questionable at best. Almost all (save several homes) in Pinion Hills have HOT WATER!
- It comes from the ground at a temperature that is so high, that it is a per se requirement that homeowners install cooling tanks.
- These cooling tanks are sometimes fitted with costly systems to help cool the water.

Non-Drinkable Water in Pinion Hills Also Necessitates Community Wells!

- In addition, the water commonly from the ground is Pinion Hills in non-drinkable. Though it may be technically potable, lab tests reflect myriad pollutants (arsenic, rust, sulfur, mercury, etc.). This means that the water is not healthful to drink. From first lab report years ago, I have cessated my consumption of the well water as being parlous (over time) and have to import bottled water. This is a liability issue for the City. Does it want to encourage more development given the water in the area is suspect? Is it prepared to expend the huge capital outlay necessary for the installation of city wells and filtering?

Carson City Cannot Ignore the Inherent Liabiltity of Perpetuating Domestic Wells!

- Governments such as Flint, Michigan have felt the LIABILITY FOR ALLOWING CITIZENS TO DRINK DANGEROUS WATER
- Carson City cannot allow new citizens to drink the visibly rust-colored sub-standard water on its east side
- THIS WILL NECESSITATE CARSON CITY DRILLING COMMUNITY WELLS
- Even then, LIABILITY EXPOSURE is exponential in comparison to the already tens of millions necessary to drill community wells

If Carson City Develops Pinion Hills- Community Wells Will be a Given!

- The existing clear-appearing potatable water of downtown Carson City is already being challenged by the EPA
- They are insisting through federal mandate that Carson City "clean up its' act" with respect to water quality in its existing downtown community wells
- In contrast the residents of Pinion Hills are on domestic wells
- The water quality of these private wells is FAR WORSE than water in the downtown from community wells
- Laboratory studies show the water is UNHEALTHFUL TO DRINK (arsnenic, sulphur, rust, etc.)

A Heavy Price Tag for Carson City!

- A City/State does not want to absorb these heavy sunk costs that are by definition exceedingly expensive for its infrastructure to support. This includes all pre-development costs related to the land conforming to like-and-kind residences.
- This entails the costs of SEWERS and COMMUNITY WELLS!

Carson City Cannot Afford Sewers and Community Wells East of Town!

- The cost of sewers and community wells for Pinion Hills will be in the tens of millions of dollars!
- The city could not afford to even do a modest upgrade to its' Waste Disposal Treatment Plant (Butti Way)!
- It had to increase the gasoline tax in order to move forward!
- This will be a <u>far more expensive proposition</u>!

Adverse Infrastructure Repercussions to Carson City

Impact Fees:

- Typically, the sale of blocks of land is made to investors with the financial wherewithal to move forward and sustain development. Specifically, the costs to a polity of development fees are passed along to the developer a function of the tenet of efficiency.
- There will be no single developer-the parcels will be sold off piecemeal via multiple private sales leaving CC to FOOT THE BILL!

The Planning Commission is Not Exercising Good Judgment in Community Planning

- Sagacious city planning commonly dictates the abandonment of private wells and septic tanks in favor of community utilities
- The Planning Commissions' thinking is backwards in that is promoting additional domestic wells and septic systems!
- It makes little sense to move forward with inadequate city infrastructure on the east side
- It would be reckless and irresponsible
- It would be cost prohibitive with respect to new "sunk" and concomitant liability costs

Existing Community Wells in Downtown Carson City Are Out of EPA Compliance! Water in P.Hills is Far Worse!

- Already, the EPA with respect to the community wells in Carson City's' downtown has raised issues. They have said that Carson City is out of compliance with respect to the its quality of water from its existing wells. This has resulted in federal mandates to "clean up our water" is a costly proposition that the city/State continue to address. Why would Carson City want to promote the sale of parcels in an area with "chump change" return (property tax revenue) (thousands) against the exponential liability/remediation costs (millions) of installing cost prohibitive east side wells?!!!

More Domestic Wells & Septic Systems Would be a Disaster!

- Are you willing Carson City to tell a child that the drinking water from a new private well is safe for him to drink? Are you willing to, as polity, absorb or underwrite this liability? Are you prepared to immediately begin concomitant development on sewers and the most modern (filtered) community wells to support this new growth? Will the paltry property tax cash flow increase even begin to cover these developmental/liability costs? Are you willing to fund this "out of pocket" as a city in recognition that there will be no impact fees or any single developer accountable?

Parcels in the Area are Suspect with Respect to Buildability

- There is a questions with respect to the underlying land
- Years ago, what is now Ambrose Park (n. Deer Run) in our neighborhood was proposed as a prospective building site
- It was rejected as the soil was too soft and there was a probability of sinking
- The same happened with respect to building at the Buzzy Anderson Ranch and Silver Saddle Ranch

Allowing More Building on Hilly Land Makes No Sense!

- Topography comes into play. Commonly a given for development is a flat parcel with no developmental issues with respect to build-ability as it relates to the land itself
- Not only are parcels in Pinion Hills largely on non-flat or "hilly" terrain, but there are NO SEWERS!
- After the last rain, Public Works was grading and sand-bagging because of no sewer infrastructure!

Development of Pinion Hills Means Carson City Will Pay a Hefty Price Tag!

- If Carson City moves forward with the disposal/sale of these parcels, then it must be ready to install city sewers and community wells. This will entail millions of dollars. As impact fees will not be paid by developers, the lots being sold "one by one," private parties will not be the "deep pockets" that city would need to recoup even a fraction of this exhaustive capital outlay. Even if the cost of sewers/community wells was passed on to homeowners via improvement bonds, the bonds could not even partially, absorb these overarching costs. It would result in property taxes for this area escalating with homeowners upset as result.

Mr. Buyer- No City Water/Sewer!

- A person purchasing a parcel is at a disadvantage developing a lot in Pinion Hills. Unlike many wells that are shallow (i.e., 40-60 feet) commonly Pinion Hills parcels-predominantly on steep sloping streets need to "drill down" much further to get water. My personal well has been drilled/deepened several times and is currently 275 feet deep (verifiable by McKay Well Drilling). In addition, the well is costly to maintain. Every few years, a pump/drilling business has to service the well. This is not a mere housekeeping expense but quite costly. The replacement of a pump commonly entails the replacement of the piping (galvanized/pvc) and wiring. Moreover, commonly the well has to be cleaned out or "flushed." This can easily translate to an unexpected cost to a homeowner (i.e., $12,000-$14000).

Just Ask Residents in Flint, Michigan How Tolerant They Were to Bad Water!

- In comparison to these extreme "sunk costs" of Carson City funding this new capital infrastructure on its East Side, the resultant liability exposure is exponential. As seen recently in Flint Michigan, the liability exposure resulted in actual liability to the polity (City/State) to the tune of hundreds of millions of dollars. The problem there was so remarkable and manifest that it made national news, elicited a federal response and EPA and other regulatory agency response.

New Property Owners Will be Complaining! Calls to Carson City Supervisors to "Fix the Problem" of Inadequate and Poor Quality Water Will Abound!

- "My water comes out of my well rust colored!"
- "The lab report says that it's not fit to drink!"
- "What happens if my children get sick?!"
- "Can you maintain accountability and pay to fix the problem?"
- "Can you establish a Internal Control Framework to monitor the quality of our water?"
- "Can you ensure that these changes will comport with regulatory laws (E.g., EPA potability)?"
- "How can your organization's liability exposure be sustainable though this existing reactive rubric? Do you want to be sued?"
- How can you create an ethical foundation to justify the sales of properties with dangerous water?

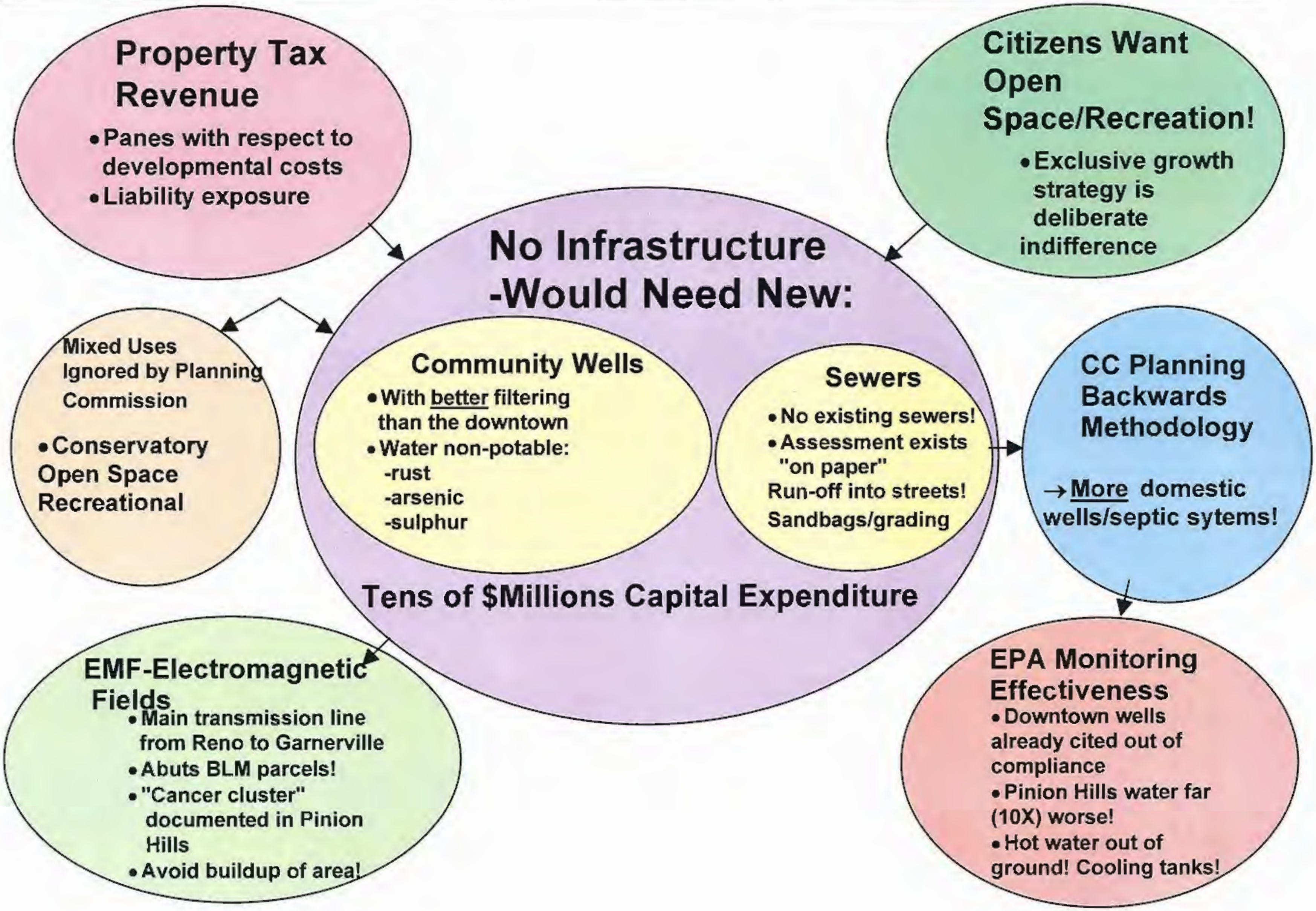
The New Property Owner Complaints Will Continue to Come In!

- Are you willing Carson City to tell a child that the drinking water from a new private well is safe for him to drink?
- Are you willing to, as polity, absorb or underwrite this liability? Are you prepared to immediately begin concomitant development on sewers and the most modern (filtered) community wells to support this new growth?
- Will the paltry property tax cash flow increase even begin to cover these developmental/liability costs?
- Are you willing to fund this "out of pocket" as a city in recognition that there will be no impact fees or any single developer accountable?

Are You Mr. Supervisor Ready to Address the EMF Liability Issue?

- How do you explain the documented "Cancer Cluster" in Pinion Hills due to the Main Electrical Lines (sourcing Gardnerville from Reno)
- They are located on the "Power Line Road" abutting the east side of Pinion Hills
- There have been class action suits throughout the country for government entities building "in reckless abandon" proximate to these lines which emit electromagnetic fields
- I myself am a cancer survivor! I was diagnosed and treated for Non-Hodgkins' Lymphoma in '00
- These dangerous lines sit in my backyard (abutting my parcel)!

Carson City Planning Commission's Flawed Development Strategy for Pinion Hills



These Concerns are Not Comprehensive but the Mere "Tip of the Iceburg"

- Other residents have other concerns that are serious and need attention prior to the development of our neighborhood
- Though "Open Space" Monies are less in the interim, more will be designated for parcel acquistion
- The thrust should be for alternative uses:
- Recreation/Open Space/Conservation
- A Draconian "sell-off" of parcels for express development is a FLAWED DECISION!!!
- It ignores the best interests of the homeowners and the community

In Conclusion

In summary the Planning Commission seeks to move forward with development that residenrs do not want!

In a closed minset, it ignores alternatives to development:

- Open space
- Conservation
- Recreation

It wrongfully assumes more revenue, but will only generate ill-affordable cost prohibitive fees.

The cost of new infrastructure will be in the tens of millions of dollars. If sewers\city wells are not installed, its non-divestible liability skyrockets!

Don't develop Pinion Hills Carson City! The residents and community-at-large don't want it! They prefer open space, conservation and recreation. Follow the good stewardship of the BLM over the past 80 years! Leave our neighborhood alone!

Questions?

From: Jacquelyn Jo
To: Stephanie Hicks
Cc: Bob Crowell; Karen Abowd; Brad Bonkowski; Lori Bagwell; jbarrette@carson.com
Subject: RE: Pinion Hills BLM property for disposal
Date: Tuesday, September 19, 2017 10:13:28 AM

Dear Stephanie,

Our family has lived in the Pinion Hills area for over 23 years. We love the "rural" atmosphere and the open areas of BLM land and the Carson River below us. We have readily taken on the geothermal water and subsequent holding tanks, reverse osmosis systems, replacement of well pumps, and minimal to no maintenance (road and drainage) by the city. Together, these issues have been a part of the "rural" living experience. However, the Pinion Hills area suffers from an ever-increasing water demand from different water users and water shortage problems. Groundwater is a vital water resource especially in the regions with limited water supplies. This is the crux of the issue and why we are adamantly opposed to the sale of the Pinion Hills surplused BLM land.

Often, development and planning in this country is a dialogue between developers and local authority planners. Unfortunately, and frequently the community and residential groups, concerned bodies and individuals are invited to come in at the last minute – struggling to add their concerns and are often treated as a nuisance by city officials. I certainly hope that the Carson City supervisors do not feel this way and will listen to the residents in this area.

Accordingly, "All manners of use of water in Nevada require a permit from the State Engineer with two exceptions – domestic use and those uses that pre-date water law requirements. A water-right application or permit is not required in order to drill a domestic well. Domestic purposes as defined by law extends to culinary and household purposes, in a single-family dwelling, the watering of a family garden, lawns, and the watering of domestic animals." (State of Nevada Engineer's website.)

Individual wells are not held to any requirement for the purchase of water rights, analysis or mitigation of impacts to the existing aquifer. The drilling of domestic water wells and installation of individual septic systems further will impact this area and its residents. There are no requirements to complete a comprehensive hydrological analysis of the impact that groundwater withdrawals have on existing water supplies or surface waters; not to mention the impact of 28 more sewer systems in the ground with the drainage going downhill to other lower homes and ultimately the Carson River. Lake Tahoe has experienced this negative impact first hand. (Lessons not learned are doomed to repeat themselves.) The effects of many wells withdrawing water from an aquifer over large area, as well as additional septic systems, may be regional in scale. If the impacts are significant, who bears that responsibility?

More houses (more wells) will undoubtedly create an ever-present strain on existing water supplies. Thus, if the sale of these lots and subsequent building of homes (potentially 28) creates a deficit in the existing water supplies, what is our legal recourse? It appears quite unfair that the very constituency the city council represents would just throw us away in the effort to sell off 14 lots for the sake of a few more dollars. If the land was surplused in 2009, and now 8 years later- and 7 years after the 1-year disposal requirement from BLM – why is it necessary to sell now? As was noted in the meeting, because the "housing market is better than it was in 2009" makes this effort appear that it is all about money. Furthermore, because of this quick movement and little notification to this community (and 7 years later after the 1-year BLM disposal time frame) one cannot help but ponder if there are underhanded dealings going on behind closed doors. Not surprisingly, many developers would be eyeing this area to avoid the expensive and complex requirements that comes with building in town or building a community system in a rural subdivision.

In addition, if more houses are built, will the city be required to maintain and upgrade the semi-rural streets and drainage systems? There will be new and ongoing city requirements and costs, since larger community systems must also undergo regular monitoring, maintenance and emergency services. Providing community support to larger community developments is made more difficult and expensive due to federal, state, and local policies within city limits.

While we recognize the need for growth, our area does not have unlimited water sources; and ostensibly, the State of Nevada itself does not have an abundance of water supplies. Will Nevada cities and the state itself learn from our negligent California neighbor? The state is and has been dealing the drastic impact of allowing overbuilding in areas that have limited water resources. Prudence dictates that there must be a limit to growth in this Pinon Hills area.

If more wells are drilled, water in aquifers will dwindle and will require some form of mitigation for the impact of even more groundwater withdrawal. We implore you to help us stop that impact before it happens and come up with a solution that is could be beneficial to the existing Pinon Hills "rural" residents and ecosystem. Please leave the surplused BLM land to a status of "open or discarded or surplused, etc." However, that outcome must occur, we will be more than willing to work with our elected officials in coming up with a mutual solution.

Thank you for your time and consideration.

Sincerely,

Kenny and Jacki Sandage

From: Laura Herrick
To: Stephanie Hicks
Subject: Pinion Pines Neighborhood
Date: Wednesday, September 20, 2017 1:38:43 PM

Dear Stephanie,

I am very concerned and disturbed about development in this area.
Water is such a huge issue. Already, without development, our well levels continue to lower. Adding more stress to this aquifer could be very detrimental to the whole neighborhood!

Additionally having a closed auction sounds pretty fishy!! Why not open it up for people with adjacent parcels so they could participate. A closed auction makes it sound like someone has a particular personal interest and legality may be another issue.

I hope the discussion is not over!

Respectfully,
Laura Herrick
1570 S. Deer Run Rd

From: Janna
To: Stephanie Hicks
Subject: Re: BLM Properties in Pinion Hills
Date: Tuesday, October 17, 2017 6:15:53 AM

This message originated outside of Carson City's email system. Use caution if this message contains attachments, links, or requests for information.

That would be very smart of them. They would make a lot more money.

Sent from my iPhone

On Oct 16, 2017, at 5:28 PM, Stephanie Hicks <SHicks@carson.org> wrote:

Hi Janna:

BLM recently advised us after further research that they could have an open bid. I wanted to let you know since you had asked previously.

Thanks,

From: Stephanie Hicks
Sent: Monday, August 28, 2017 10:47 AM
To: 'Janna'
Subject: RE: BLM Properties in Pinion Hills

Janna:

Here is the pdf of the notice with the map.

From: Janna [redacted]
Sent: Monday, August 28, 2017 10:25 AM
To: Stephanie Hicks
Subject: Re: BLM Properties in Pinion Hills

This message originated outside of Carson City's email system. Use caution if this message contains attachments, links, or requests for information.

Is it possible to get an emailed copy of the properties that are going to be sold?

Sent from my iPhone

On Aug 28, 2017, at 10:02 AM, Stephanie Hicks <SHicks@carson.org> wrote:

Hi Janna:

I just heard back from BLM. Yes, the bids will be sealed. The bids will be

sealed. The bidding procedures are outlined here:
https://www.law.cornell.edu/cfr/text/43/2711.3-1

If you have any other questions, please let me know.

Thanks,

From: Janna [redacted]
Sent: Wednesday, August 23, 2017 2:17 PM
To: Stephanie Hicks
Subject: Re: BLM Properties in Pinion Hills

So the bidding process won't be sealed?

Sent from my iPhone

On Aug 23, 2017, at 1:59 PM, Stephanie Hicks <SHicks@carson.org> wrote:

> Hi Janna:
>
> Nice to hear from you and thanks for reaching out. The open house will not be webcast. However, the comments and input we receive will all be part of any item we bring forward to the Board of Supervisors for direction. At this point, we hope to present to the Board on October 5th, but that could change. The Board meetings are always webcast.
>
> Victoria advised us of the status of your driveway. Thank you for continuing to pursue that and we appreciate the update.
>
> To answer your questions, BLM will sell the parcels through an open competitive bid process starting at fair market value. The reality is that if this goes forward, it will be a couple years before the properties are up for sale. Each parcel will be sold individually but it is likely they will go up for sale at the same time.
>
> If you have any other questions, please do not hesitate to ask.
>
> ---
>
> **From:** Janna [redacted]

Sent: Wednesday, August 23, 2017 12:14 PM
To: Stephanie Hicks
Subject: BLM Properties in Pinion Hills

Hello Ms. Hicks!

This is Janna Tisea, property owner at 1127 Pinion Hills Dr. I received your letter about the open house that you will be having on Tuesday, unfortunately, I will be unable to attend. Will it be webcasted?

As for my situation with the neighboring property (you recall I have a driveway that crosses it). I have filed an application with BLM. Also, I have spoken with Victoria Wilkins and it is my intention to purchase a perpetual right of way for that driveway at the time that BLM transfers the property to its new owner. If anyone asks about our driveway at the informational meeting, you can tell them that that is our intention.

As for the sale of the other properties, is it still expected to be a sealed bid sale? Will all the properties be sold at the same time or individually?

Very Best,

Janna Tisea

MAHE LAW, LTD.
707 North Minnesota Street, Suite D, Carson City, NV 89703

September 19, 2017

Stephanie A. Hicks,
Carson City Real Property Manager
3505 Butti Way
Carson City, NV 89701

Re: Sale of Real Property in Pinion Hills

Dear Ms. Hicks:

Please accept this as a supplement to our correspondence dated September 18, 2017, on behalf of my client Kirby Nish. Mr. Nish has completed some additional research that resulted in information he believes will be beneficial to Carson City in considering the sale of real property in the Pinion Hills neighborhood. Specifically, he has completed research regarding the water quality standards issue and located the Ground-Water Quality Assessment of the Carson River Basin, Nevada and California – Results of Investigation, 1987-91 completed as part of the United States Geological Survey by the Department of the Interior and Nevada's 2002 303(d) Impaired Waters List, copies of which are enclosed for your convenience. As he noted, these documents indicate that Nevada's standards are consistently tempering down the water quality standards of the federal government and he remains concerned as to the impact that such tempering down will have should the substantial property in Pinion Hills be sold. Additionally, for your information, Mr. Nish believes that mining operations were historically conducted in close proximity to the Pinion Hills neighborhood which could explain some of the water quality issues encountered in that area.

Should you have any questions or concerns please do not hesitate to contact my office.

Sincerely,

JENNIFER MAHE

Encls.

Cc: Client
Carson City Board of Supervisors via Nick Marano, City Manager

DRAFT
Nevada's
2002 303(d) Impaired
Waters List

Prepared by:

Nevada Division of Environmental Protection
Bureau of Water Quality Planning
June 2002

To comment on this DRAFT List, contact:

Randy Pahl
Nevada Division of Environmental Protection
Bureau of Water Quality Planning
333 W. Nye Lane, Room 138
Carson City, NV 89706
(775) 687-4670, ext. 3161
Email: rpahl@ndep.state.nv.us

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DRAFT Nevada's 2002 303(d) Impaired Waters List

Introduction

Section 303(d) of the Clean Water Act requires that States develop a list of waterbodies needing additional work beyond existing controls to achieve or maintain water quality standards. This list, referred to as the Section 303(d) List, provides a comprehensive inventory of water bodies impaired by all sources, including point sources, nonpoint sources, or a combination of both. The 303(d) List is the basis for targeting water bodies for watershed-based solutions, and the Total Maximum Daily Load (TMDL) process provides an organized framework to develop these solutions.

Subpart C of 40 CFR (Code of Federal Regulations) Part 130 requires that states develop descriptions of the criteria and process used in generating their 303(d) lists. Following is a summary of the methodology utilized by the Nevada Division of Environmental Protection (NDEP) in developing the 2002 303(d) List and the listed waterbodies.

On July 11, 2000, past EPA Administrator Carol Browner signed new TMDL rules which represent significant changes to the current regulations and to content and format requirements of the 303(d) List. However at this time, the new TMDL regulations are not in effect and the exact future of these regulations is unknown. Because of the controversy, Congress prevented the implementation of the rule through passage of an appropriations bill which prohibits the obligation or expenditure of Fiscal Years 2000 and 2001 funds for the new TMDL rules or for any related technical assistance or guidance. This action moved the effective date of the rules to October 1, 2001. On July 16, 2001, EPA announced its plan to propose an 18-month extension of the effective date of the rule to provide time to review and possibly revise the rule. On October 18, 2001, the TMDL rule delay was made official. As a result of this action by EPA, the 2002 303(d) List is due to EPA on October 1, 2002 and the new TMDL rules have been delayed until April 30, 2003. Therefore, the 2002 303(d) List was developed in accordance with the current regulations.

Background on Water Quality Standards

Nevada's water quality standards, contained in the Nevada Administrative Code (NAC) 445A.119 – 445A.225, define the water quality goals for a waterbody, or a portion of a waterbody, by: 1) designating beneficial uses of the water; and 2) setting criteria necessary to protect the beneficial uses. Beneficial uses include, but are not limited to, irrigation, recreation, aquatic life, fisheries, and drinking water. In many instances, NAC defines two or more reaches for a river system, with each reach possibly having different beneficial uses and water quality standards.

Both narrative and numeric criteria are included in Nevada's water quality standards. The narrative standards are applicable to all surface waters of the state and consist mostly of statements requiring waters to be "free from" various pollutants including those that are toxic.

The numeric standards for conventional pollutants are broken down into two types: class and waterbody specific. For the class waters, criteria for various pollutants are designed to protect the beneficial uses of classes of water, from A to D; with class A being the highest quality. The waterbodies belonging to these classes are named in the regulations.

For major waterbodies in Nevada, site-specific numeric standards have been developed. These waterbodies are often referred to as "designated" waters. The standards for designated waters include both criteria designed to protect the beneficial uses and antidegradation requirements. The antidegradation is addressed through the establishment of "requirements to maintain existing higher quality" or RMHQs. RMHQs are set when existing water quality (as evidenced by the monitoring data) for individual parameters is higher than the criteria necessary to protect the beneficial uses. This system of directly linking antidegradation to water quality standards provides a manageable means for implementing antidegradation through permits and other programs.

General Listing Criteria

The criteria for listing were developed to identify only those waterbody segments for which there is adequate documentation that beneficial uses are not being supported and water quality standards are not being met. In evaluating a given waterbody, NDEP considered "all existing and readily available water quality related data and information" such as chemical/physical properties of water column, sediment and fish tissue; biological information; toxicity testing results; narrative and qualitative information.

In general, a waterbody was included on the 2002 303(d) List when there is adequate documentation that beneficial uses were not being supported and/or beneficial use standards (NAC 445A.119 through 445A.225, including narrative and numeric standards) were not being met during the five-year period 1997 through 2001. Also, a waterbody was included on the 303(d) List if:

- A fishing, drinking, or swimming advisory had been in effect for the waterbody during the listing period.
- The waterbody was listed on a prior 303(d) List and insufficient information exists to delist the waterbody.

In developing the List, NDEP considered both beneficial use standards (BUs) and RMHQs. However, separate lists were developed for waterbodies exceeding BUs versus RMHQs. BUs were evaluated in developing the 2002 303(d) List. Waterbodies not meeting RMHQs are identified in a separate table for which TMDLs are not required.

Evaluating Numeric Standards and Data

For most waterbodies, the most comprehensive readily available water quality related data/information were physical and chemical water column monitoring data, and widely distributed scientifically defensible special studies (including chemical and biological information). Other types of data (sediment, fish tissue, narrative information, etc.) are generally not as common for Nevada waterbodies. While NDEP examined all types of readily available data, a majority of the listing decisions were based upon numeric data primarily because these types of data are most common.

In general, a waterbody was included on the 2002 303(d) List if any of its numeric beneficial use standards were exceeded more than 10 percent of the time during the five-year listing period (January 1, 1997 to December 2001). There are some exceptions to this general rule as discussed in subsequent sections of this report.

Data Sources and Requirements

Data and Information Sources

As required by Section 303(d) of the Clean Water Act and Section 130.7(B)(5) of CFR, NDEP will compile and consider "all existing and readily available water quality related data and information" in identifying listed waters. Existing and readily available data and information includes, but is not limited to, the following:

- Most recent 303(d) List;
- Most recent 305(b) Report;
- Clean Water Act 319 nonpoint source assessments;
- Drinking water source water assessment under Section 1453 of the Safe Drinking Water Act;
- Dilution calculations, trend analyses, or predictive models for determining the physical, chemical or biological integrity of streams, rivers, lakes and estuaries; and
- Data, information, and water quality problems reported from local, State, Territorial, or Federal agencies (especially the USGS National Water Quality Assessment (NAWQA) and National Stream Quality Accounting Network (NASQAN)), Tribal governments, the public, and academic institutions.

While NDEP is required to ***consider*** waterbodies identified in the 305(b) as "not fully supporting", NDEP is not required to include all such waterbodies in the 303(d) List. In fact, the two reports are developed using data for different time periods and using different methodologies. As a result, waterbodies identified as impaired on the 305(b) lists may not meet the 303(d) listing criteria. It must be noted that the 303(d) List and the 305(b) Report are setforth in the Clean Water Act to meet different needs. While the 303(d) List identifies waterbodies in need of additional actions, the 305(b) Report has been intended to serve as a summary report to Congress on states water quality conditions. States and EPA are recognizing the confusion these two reports create for the public and the agencies. Nevada and other states are moving toward an integrated 303(d)/305(b) report in the future.

The State of Nevada operates a monitoring program which encompasses the States 110,000 acres, regularly monitoring over 100 sampling points in the 14 hydrographic regions found in the state (Appendix E). In addition to these fixed monitoring stations, several water quality intensive field studies are conducted on the major water systems of Nevada. These studies included

Truckee River, Carson River, Walker River and the Humboldt River. In addition a number of lakes and reservoirs have been added to the monitoring program. As part of the monitoring, samples are collected from each major river basin in the state, and then analyzed for physical and chemical quality. In addition to this numeric information, NDEP also collects information pertinent to Nevada's narrative water quality standards.

Additional data was solicited from other entities prior to the completion of the 2002 303(d) List. Also, the public notice and comment period provided the opportunity for additional individuals and groups to present additional monitoring data, ongoing research or other publications for consideration. However, it is important that the decision to list a water body be based upon credible evidence.

It is relatively straightforward to define methods for evaluating numeric data for numeric standard compliance. However, it is much more challenging to define how other types of data and information will be used in the listing process. Other types of data and information that are available include:

- Fish tissue data
- Contaminated sediment data
- Toxicity testing data
- Bioassessment data and information
- Qualitative information or other studies

In general, NDEP examined these types of available information in order to identify evidence that any of the beneficial uses were impaired during the period 1997-2001. The data sources and decisions supporting each listing decision are documented in the appendices.

Minimum Data Requirements and Listing

With a few exceptions, most of the listings in the 2002 303(d) Impaired Waters List were based upon data meeting the following minimum requirements:

- For the waterbodies in question, at least 10 water quality sample analyses were available for the five-year period January 1, 1997 and December 31, 2001.
- There were a sufficient number of samples to represent conditions in the waterbody reach during the five-year period. Best professional judgment was utilized to make this determination. Basically, the available samples were considered representative if collected during a variety of flow regimes and seasons throughout the five-year listing period and not biased toward extreme or unusual conditions. As discussed in the "Accounting for Extreme Events" section, data associated with samples collected during extreme high or low flows were not considered in the listing analysis.
- There was adequate documentation on data development and sampling location.

Waterbodies were included on the 303(d) List if any of its numeric beneficial use standards were exceeded more than 10 percent of the time during the five-year listing period (January 1, 1997 to December 2001). The decision to set a minimum number of samples for consideration was driven by our need to provide a clear definition of the criteria with results that are reproducible by others to the extent possible, and to provide a level of statistical reliability to our decisions.

In general, the goal for the 303(d) List was to identify those waters that are exceeding water quality standards over 10% of the time. However, the true exceedance percentage for most waterbodies and water quality criteria is unknown due to the limited data resulting from monthly or less frequent sampling. The State of Florida has investigated the issue of minimum sample size for listing decisions from a statistical perspective. One basic conclusion was that greater sample sizes result in more reliable estimates of the true standards exceedances in a waterbody. The investigators recommended that a minimum of 10 samples be required for assessing impairment. NDEP deemed this to be an appropriate minimum threshold for data used in the listing decisions.

It must be noted that a few waterbodies were listed with sample sizes less than 10. For those waterbodies, other information such as severity, frequency and magnitude of the exceedances, and sediment, fish tissue, biological conditions warranted listing. The data sources and decisions supporting each listing decision are documented in the appendices.

NDEP thought it important to identify those waterbodies with minimal water samples but had the potential for water quality problems. With this in mind, a "Potential Problems" list was included. In general, a waterbody were included on this list if there was not sufficient evidence to place the waterbody on the 303(d) List, but there was evidence from available data and information that a potential problem exists. This list is intended to serve as a planning tool for future NDEP assessment activities. TMDLs are NOT required for these waterbodies

As stated earlier, there were a few exceptions to the above 303(d) listing criteria. A few waterbodies, which did not meet the above listing criteria, were placed on the 2002 303(d) List because:

- A fishing, drinking, or swimming advisory had been in effect for the waterbody during the listing period indicating an impairment of a beneficial use for over 10% of the 5-year listing period.
- The waterbody was listed on a prior 303(d) List and insufficient information exists to delist the waterbody.
- Other information existed indicating impairment of beneficial use(s).

The data and information used in placing a waterbody on the List are documented in the appendices.

Detection Limits

Frequently, toxics concentrations in Nevada rivers are less than the detection limit[1] of the applicable laboratory procedure. According to Footnote (3) in NAC 445A.144, if the water quality standard:

> "…is less than the detection limit of a method that is acceptable to the division, laboratory results which show that the substance was not detected [below detection limit] will be deemed to show compliance with the standard unless other information indicates that the substance may be present."

Therefore for purposes of developing the 303(d) List, samples with toxic concentrations reported "as less than the detection limit" were assumed to comply with the water quality standards, but only if:

- the certified laboratory method is acceptable to NDEP; and
- no other information indicates that the substance in question exists in levels detrimental to the beneficial uses.

Toxics

NAC 445A.144 defines water quality standards for various toxic materials that are applicable to the water specified in NAC 445A.119 through 445A.225. For some of these constituents, the standards set 1-hour average (acute) and 96-hour average (chronic) maximum acceptable concentrations, with the 96-hour criteria being the most restrictive. For listing purposes, the available water quality data associated with grab samples were compared to only the 1-hour criteria and the 96-hour criteria. In general, a waterbody was placed on the list if the grab sample concentrations exceeded the 1-hour criteria in more than 10% of the samples. It must be noted that most of the data analyzed for this report were derived from monthly (or less frequent) grab samples and that grab samples may not be representative of conditions over a 4 day period depending upon the waterbody and constituent. For that reason, waterbodies exceeding the 96-hour criteria in more than 10% of the samples were placed on the "Potential Problems" list, unless 303(d) listing was warranted based upon other information such as biological data indicating impairment, or severity of exceedances.

Accounting for Extreme Events

Drought and flood period are a part of the natural process, and data that shows impairment as a result of a major drought or flood event should not serve as the listing basis. Nevada Administrative Code 445A.121(8) states, "The specified standards are not considered violated when the natural conditions of the receiving water are outside the established limits, including periods of extreme high or low flow ...." Therefore, water chemistry data associated with samples collected during extreme high and low flows[2] were not considered in the listing analysis.

---

[1] Detection limit is the minimum concentration of a constituent that can be detected using a particular laboratory procedure.

[2] $7Q10_{high}$ and $7Q10_{low}$ values as developed by USGS were used to establish the extreme flow conditions. The 7Q10 flows were developed from historic streamflow data and are defined as a predicted high or low flow for a consecutive seven day period with an expected recurrence interval of ten years.

Field and Laboratory Data

In the case of pH, many of the available datasets include both field and laboratory values. Since pH can change over time before the sample arrives at the laboratory, the field pH is felt to be the more accurate measure. Therefore, field pH was the primary value evaluated for standards compliance. However, laboratory pH was utilized in some instances where field pH was not available.

Biological Assessments

Starting in 2000, NDEP has been performing biological assessments on the major waterbodies in Nevada. Data and information are being collected concerning macroinvertebrate abundance and diversity, and physical habitat conditions. As this program is in its infancy, none of NDEP's biological assessment or bioassay information were used in the 303(d) listing analysis. Biological assessment protocols will be developed as NDEP collects additional data. Some macroinvertebrate data were submitted to NDEP for consideration, but without any evaluation protocols and criteria specific to Nevada, BWQP was not able to incorporate these data into our listing decisions. As the biological assessment program develops, BWQP will be better suited to evaluate biological data for determinations of beneficial use support.

Continuous Monitoring Data

Past 303(d) Lists have been developed based primarily upon grab sample data, which represent quality conditions for a specific point in time. Data collected on a more continuous basis, e.g. hourly or other frequencies, needs to be considered during the 303(d) List development. In recent years, NDEP and other groups have undertaken continuous monitoring of some parameters (such as dissolved oxygen, temperature, pH and specific conductance) for selected waterbodies. In most cases, the available continuous monitoring data did not have a complete record set for the five-year listing period (January 1, 1997 to December 31, 2001). These data were evaluated as follows for inclusion on the List:

- Each day of available data was examined to determine the number of violations. If the standards were violated for any length of time for a given day, it was considered as one violation.
- A reach was listed if standard violations occurred for more than 10% of the 1,826 days in the five-year period.

Additional Considerations during the Listing Assessments

Standards, Control Points and the Tributary Rule

For the major waterbodies, NAC sets water quality standards for specific control points (see NAC 445A.145). On a given stream, the standards apply to that control point and for the remainder of the river upstream, all surface waters upstream (in Nevada) or to the next control point upstream, if any. If there are no control points downstream from a particular control point, the standards for that control point apply for the remainder of the stream downstream, all surface waters downstream (in Nevada) or to the next waterbody downstream named in NAC. As a result, NAC has effectively divided many of the streams into reaches with varying standards.

As stated earlier, NDEP operates an extensive water quality monitoring network throughout Nevada. In many cases, the associated sampling locations are at control points. Data collected at these control points are evaluated as part of the listing process. If the standards are violated (in accordance to the criteria described herein) at the control point, the entire reach associated with that control point was listed unless there is available information to divide the reach into subreaches. In fact, there are some instances where two or more monitoring stations are located on a reach. These data were examined to determine whether or not to list the entire reach or only subreaches.

NAC 445A.145 is commonly referred to as the "tributary rule." In general, the tributary rule provides additional water quality criteria for those surface waters (in Nevada only) that are not defined as a class water (NAC 445A.123 through 127) nor as a designated water (NAC 445A.146 through 225). For those waters that are unclassified and undesignated, the water quality criteria for the nearest control point or classified water (upstream or downstream) may be applied to these water bodies in the listing analysis under certain conditions. According to NDEP's Continuing Planning Process document, the tributary rule is to be applied to an unclassified and undesignated water in the listing analysis if:

- there was a hydrologic connection during the listing period not just in response to storm events; and
- the hydrologic connection was for a long enough period such that a commingling of water and an exchange of beneficial uses, in particular aquatic life, was possible.

For purposes of the 2002 303(d), the tributary rule was applied to a given waterbody if USGS topographical maps showed a connection between the waterbody in question and a designated or class water. Tributary application decisions are denoted in the appendices.

Designated and Class Waters

The water quality of both the designated and the class waters will be evaluated for potential inclusion on the 2002 303(d) List. In general, only designated waters were included in past 303(d) Lists.

Single Value and Annual Average/Median Standards

For some reaches, the water quality standard for a parameter is defined in terms of a maximum annual average or annual median concentrations. The reach was listed if the annual average or median values exceeded the beneficial use standard at least once during the five-year listing period.

Some reaches have both single value standards and annual average standards for certain parameters. If either the single value standard were exceeded more than 10% of the time (assuming a minimum of ten samples) or the annual average standard was exceeded at least once, the reach was listed for that particular parameter.

Antidegradation Considerations

Nevada Revised Statutes (NRS) 445A.565 contain the State's antidegradation requirements. NRS 445A.565 states:

> "Any surface waters of the state whose quality is higher than the applicable standards of water quality as of the date when those standards became effective must be maintained in their higher quality. No discharges of waste may be made which will result in lowering the quality of these waters unless it has been demonstrated to the commission that the lower quality is justifiable because of economic or social considerations. This subsection does not apply to normal agricultural rotation, improvement or farming practices"

NRS 445A.565 is implemented through the establishment of requirements to maintain existing higher quality (RMHQs). An RMHQ is established when the monitoring data show that existing water quality for individual parameters is significantly better than the standard necessary to protect the beneficial uses. If adequate monitoring data exist, RMHQs are established at levels which reflect existing conditions. This system of directly linking antidegradation to numeric objectives provides a manageable means for implementing antidegradation through permits and other programs. In general, past Nevada 303(d) Lists have been developed based upon violations of the beneficial use standards and not the RMHQs. However in the case of the Truckee River, TDS was placed on the 1992 303(d) List due to violations of the TDS RMHQ. For this report, waterbodies violating RMHQs (in general, more than 10% of the time for sample sizes of 10 or greater) were placed in a separate table entitled "Waterbodies not meeting RMHQs (Requirements to Maintain Higher Water Quality)." TMDLs are NOT required for these waterbodies.

Tribal Water Quality Standards

Tribes have independent authority for setting water quality standards and implementing regulations for waters on reservation land under the 1987 Amendments to the Clean Water Act (CWA). At this time, the State of Nevada regulations include water quality standards for waterbodies on tribal lands throughout Nevada. However the State of Nevada has no authority to set standards on tribal lands, therefore the 2002 303(d) List does not included any impaired waterbodies that exist on tribal lands.

Natural Condition-Based Water Quality Standards

There are several instances in the regulations where the water quality criteria are defined as a certain level above or below the "natural conditions[3]" (Table 1). Application of these standards to the 303(d) listing process is difficult due to problems in quantifying natural conditions. In order to quantify natural conditions, data representing pre-human development conditions are needed. However, most of the available water quality data are based upon samples collected after upstream human impacts have occurred.

Violations of the natural condition-based standards were not evaluated for impairment status on the 2002 303(d) List, except for fecal coliform and TDS as follows:

> <u>**Fecal coliform:**</u> Criteria 1 and 3 in Table 1 are not natural condition-based standards and will be used in the listing analysis.
>
> <u>**TDS:**</u> The natural conditions portion of the standard will not be used, however the maximum TDS level of 500 mg/l in Table 1 will be used in the listing analysis.

NDEP is in the process of revising these natural condition-based standards to numeric criteria that are measurable and defensible.

Natural Background Considerations

In instances where a water quality standard is exceeded due solely to naturally occurring conditions, the exceedance is not considered a violation of the water quality standard. Refer to the following NAC references:

> NAC 445A.120(2) states:
>
> "...Natural water conditions may, on occasion, be outside the limits established by standards. The standards adopted in NAC 445A.120 to 445A.213, inclusive, relate to the condition of waters as affected by discharges relating to the activities of man."
>
> NAC 445A.121(8) states:
>
> "The specified standards are not considered violated when the natural conditions of the receiving water are outside the established limits, including periods of extreme high or low flow..."

[3] "Natural conditions" are considered to be the water quality characteristics that would exist in a waterbody without the impacts of modern human development. The Nevada Administrative Code does not define "natural conditions", but does provide the following definition of "natural waters" – "...waters which have not been degraded or enhanced by actions attributable to man."

Table 1. Summary of Natural Condition-Based Water Quality Standards

Parameter	Applicable Water Class	Standard
Alkalinity	various designated waters	"less than 25% change from ***natural conditions***"
Color	various designated waters	"Increase in color must not be more than 10 PCU above ***natural conditions.***"
Fecal coliform	Class C only	The more stringent of the following apply: "1. The fecal coliform concentration must not exceed a geometric mean of 1000 per 100 milliliters nor may more than 20 percent of total samples exceed 2400 per 100 milliters." "2. The annual geometric mean of fecal coliform concentration must not exceed that characteristic of ***natural conditions*** by more than 200 per 100 milliliter nor may the number of fecal coliform in a single sample exceed that characteristic of ***natural conditions*** by more than 400 per 100 milliliter." (italics added) "3. The fecal coliform concentration, based on a minimum of 5 samples during any 30-day period, must not exceed a geometric mean of 200 per 100 milliliters, nor may more than 10 percent of total samples during any 30-day period exceed 400 per 100 milliliters. This is applicable only to those waters used for primary contact recreation."
Total Dissolved Solids	Class A, B and C waters	"must not exceed 500 mg/l or one-third above that characteristic of ***natural conditions*** (whichever is less)."
Turbidity	various designated waters	"Increase in turbidity must not be more than 10 NTU above ***natural conditions.***"

In determining whether or not a waterbody is impaired due solely to natural causes, NDEP examined available information and applied best professional judgment. The type of information needed for a waterbody to be considered as naturally impaired include (but not limited to):

- Human activities (e.g. urbanization, grazing, mining) within the affected waterbody shown not to be significant source of pollutant in question.
- The pollutant in question is known to occur naturally in the form found in the reach.
- A probable natural source (i.e. hot springs, mineralized outcropping) is located within the watershed.

During the development of the 2002 List, no waterbodies were found at this time to qualify as "impaired by natural causes." Additional studies are needed for some waterbodies to determine whether or not impairments are due to natural causes.

Narrative Standards

Narrative standards appear in two locations in the regulations:

> NAC 445A.121 contains narrative criteria that are applicable to all surface waters of the state and consist mostly of statements requiring waters to be "free from" various pollutants in sufficient levels so as to not: 1) be unsightly; 2) interfere with any beneficial uses; 3) create a public nuisance; 4) be toxic to human, animal, plan or aquatic life; etc.
>
> NAC 445A.203 – 445A.208 (Humboldt River) includes criteria which states that color is to not have "adverse effects" on the beneficial use (with municipal and domestic supply being the most restrictive use).

One example of available qualitative information includes information collected by NDEP. When grab samples are collected as part of NDEP's monitoring network operations, staff also notes whether or not the water contains substances attributable to domestic or industrial waste or other controllable sources including:

- Settleable solids that form bottom or sludge deposits;
- Floating debris;
- Oil, grease, scum and other floating materials;
- Odor; and
- Color, turbidity or other conditions.

These qualitative observations did not lead to any new listings but did confirm some listings that were based upon water column chemistry.

Some data submitted to NDEP for consideration were for waterbodies that have no specific numeric criteria and are not tributary to waterbodies with criteria. In these instances, only NAC 445A.121 provides narrative criteria. For these waterbodies, there were insufficient data to list as impaired. However, some of these waterbodies were included on the "Potential Problems" list.

Special Considerations for Lakes

NDEP collects samples at a number of lakes throughout Nevada, however in some instances the sampling points are limited to one point that is easily accessible to the monitoring crew. The same may be true for other entities and their sampling programs. Depending upon the parameter in question, the resulting water quality data may or may not be representative of conditions in the lake. For instance, the samples may have been collected near shore at high use areas with water quality representative of only a limited portion of the lake. Other samples collected further out in the lake may indicate different water quality conditions. For the 2002 303(d) List, the available water quality data (whether near-shore or mid-lake samples) were examined for compliance with the standards and list inclusion. Future monitoring may be needed for some waterbodies to verify the suitability of the lake monitoring sites.

Delisting

As a general rule of thumb, it should take similar data to delist as to list. In other words, if the procedures described above are found to indicate a waterbody is not impaired, the waterbody will be delisted. Other reasons to delist include:

- The standard is no longer exceeded because of a change in the surface water quality standards.
- Faulty data or information, or errors in the analysis resulted in a listing error.

The above list is not intended to be inclusive of the only criteria considered for de-listing. NDEP reserves the right to use data or information that goes beyond the above criteria, and can include other types of information and best professional judgment. The lack of data was never justification for delisting a waterbody. For the 2002 303(d) List, waterbodies were delisted for the following reasons:

- the available 10 or more samples indicated exceedances at less than 10 percent;
- the waterbody was erroneously included on the 1998 303(d) List; and
- the waterbody is on tribal land.

TMDL Prioritization Schedule

40 CFR Part 130 requires that TMDLs be developed for those waterbodies on the 303(d) List, and that the 303(d) List contain a prioritized schedule for establishing TMDLs for these waters. Prioritizing water bodies enables the state to make efficient use of available resources to meet the objectives of the Clean Water Act. Priority ranking takes into account the severity of the pollution and the uses to be made of such waters.

Targeting high priority waters for TMDL development reflects an evaluation of the relative value and benefit of water bodies within the state. The priority ranking was developed taking into consideration the following (not in order of priority):

- Risk to human and aquatic life
- Degree of public interest and support
- Recreational, economic, and aesthetic importance of a particular waterbody
- Vulnerability or fragility of a particular waterbody as an aquatic habitat
- Immediate programmatic needs such as:
    - waste load allocations
    - permits to be issued
    - new or expanding discharges
    - load allocations for needed Best Management Practices (BMPs)
- Severity of the impairment and the designated water uses
- Data availability
- Potential changes to water quality standards

- Appropriateness of standard
- TMDL complexity

The 2002 303(d) List (Appendix A) presents the TMDL development priorities for the various listed waterbodies as determined by the Bureau of Water Quality Planning based upon existing resources. In general, the following schedule applies for the different priority levels:

- High priority: 0 to 2 years
- Medium priority: 2 to 5 years
- Low priority: beyond 5 years

Summary of Methodology and Findings

Section 303(d) of the Clean Water Act requires that States develop a list of waterbodies needing additional work beyond existing controls to achieve or maintain water quality standards. This list, referred to as the Section 303(d) List, provides a comprehensive inventory of water bodies impaired by all sources, including point sources, nonpoint sources, or a combination of both. The 303(d) List is the basis for targeting water bodies for watershed-based solutions, and the Total Maximum Daily Load (TMDL) process provides an organized framework to develop these solutions.

Subpart C of 40 CFR (Code of Federal Regulations) Part 130 requires that states develop descriptions of the criteria and process used in generating their 303(d) lists. This report summarizes the basic methodology NDEP used in developing the 2002 303(d) List. The 2002 303(d) List is included in Appendix A. In addition to impaired waters, this report also identified waterbodies in need of additional review:

- **List of Waterbodies with Exceedances of RMHQs:** Represents violations of Requirements to Maintain Higher Water Quality, TMDLs are not required (Appendix B)
- **List of Waterbodies with Potential Problems:** Represents waterbodies with possible water quality problems, TMDLs are not required. (Appendix C)
- **Delisted Waters:** Waterbodies that were on the 1998 303(d) List but no longer qualify for inclusion as impaired on the 2002 303(d) List (Appendix D)

As stated above, the 303(d) Impaired Waters List begins to define those waterbodies in need of TMDLs as part of the solutions for a given waterbody. The next 2 tables included in this report (Waterbodies with Exceedances of RMHQs, and Potential Problems) identify waterbodies in need of additional review which could include additional monitoring, standards review and revision, or inclusion on future 303(d) List. Appendix D includes waters removed from the 303(d) List.

There are approximately 14,988 miles of perennial rivers and streams, 126,257 miles of intermittent/ephemeral streams and channels, 1,782 miles of ditches/canals and 551 border miles of shared rivers. Nevada has approximately 1,070 lakes, reservoirs or ponds with a approximate total acreage of 533,239 (these river and lake sizes are according to EPA's "Total Waters

Report") and approximately 136,650 acres of wetlands. The 2002 303(d) Impaired Waters List identifies approximately 1614 river miles as impaired, an increase of about 700 miles from the 1998 303(d) List. An additional 45 stream reaches appears on the 2002 List compared to the 1998 List. The most common causes of impairment for all listed streams is nutrient and metals, followed by sediment, temperature, totals dissolved solids, pH and other parameters (Table 2). Impaired lake and reservoir acreages have increased from 36,812 acres in 1998 to 77,974 acres in the 2002 303(d) List. Impaired wetland acreages increased from 31,326 acres in 1998 to 31,511 acres in the 2002 List. The number of listed river miles and acreages have increased from the 1998 303(d) List due to changes in the listing methodology and the implementation of new standards, not from degradation of the water quality.

Table 2. Summary of Impaired Waterbodies and Associated Parameters

Parameter	Impaired Rivers, miles	Impaired Lakes/Reservoirs, acres	Impaired Wetlands, acres
TOTAL	1,614	77,974	31,511
Nutrients	1,070	39,642	185
Metals	1,070	0	31,326
Sediment	672	0	0
Temperature	535	42,474	0
pH (existing standards)*	363	4,674	185
Total Dissolved Solids	251	35,500	185
Other	44	36,812	0

* When the pH standards are updated based upon current EPA guidance, the n number of river miles impaired by pH will drop to about 24 miles (See discussion under ***Statewide Observations***). The total river miles listed as impaired will drop from 1614 to 1589 river miles. The extent of impaired lakes, reservoirs, and wetlands will not change with a pH criteria revision.

Current Status of TMDL Development

Established TMDLs

Table 3 summarizes the TMDLs that have been established by NDEP and approved by EPA. The following discussion provides information on the status of these TMDLs and any efforts to modify.

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Table 3. Summary of Established TMDLs

Basin	Parameters	Reference
Carson River	BOD, nitrate, orthophosphates, TDS	208 Plan for the Carson River Basin (NDEP, 1982)
Humboldt River	TDS, TP, TSS	208 Plan for Non-Designated Areas (NDEP, 1993)
Las Vegas Wash/Bay	TP, total ammonia	Rationale and Calculations for TMDLs and WLAs for Las Vegas Bay (NDEP, 1988)
Truckee River	TDS, TN, TP	Truckee River Final TMDLs and WLAs (NDEP, 1994)
Walker River	TSS	208 Plan for Non-Designated Areas (NDEP, 1993)

BOD = biochemical oxygen demand
TDS = total dissolved solids
TN = total nitrogen
TP = total phosphorus
TSS = total suspended solids

Carson River: *Water Quality Management (208) Plan for the Carson River Basin, Nevada* (1982) contains maximum allowable daily loads for dissolved oxygen, biochemical oxygen demand, orthophosphates, nitrates and total dissolved solids, which were developed utilizing a detailed water quality modeling study. However, this TMDL is confusing, and needs to be updated to reflect current water quality standards and conditions on the river. NDEP is in the process of updating the Carson River TMDL. It is anticipated that some updates will be developed by 2003.

Humboldt River: The existing TMDLs for total suspended solids (TSS) and total phosphorus (TP) are included in Nevada's Nondesignated Areas 208 Plan (NDEP 1993). However, the existing TMDLs oversimplify a complex situation and do little to characterize sources to the level needed for a meaningful implementation plan. Additional work is needed to better identify sources in terms of their contributions and locations.

The water quality standards for the Humboldt River were revised in November 1995. As a result of revisions to the water quality standards for TP and TSS, the existing TMDLs need to be reevaluated. NDEP plans to revised the current TMDL in the future, however, it must be noted that significant additional assessments are needed before a more meaningful TMDL can be realized.

Las Vegas Bay/Wash: In 1987, NDEP established total phosphorus and total ammonia WLAs in the Las Vegas Wash at Northshore Road as needed to meet the Las Vegas Bay water quality standards. The WLAs set are applicable for only April through September and were based upon target concentrations (0.64 mg/l – total phosphorus, 1.43 mg/l total ammonia) developed by French (*Concentration Estimates at Northshore Road to Meet Water Quality Standards in Las Vegas Bay*, 1988), and average streamflows. In 1994, Dr. French (*Concentration Estimates at Northshore Road to Meet Water Quality Standards in Las Vegas Bay*, May 1994), re-examined these target concentrations. Of particular interest was the possible impact of increasing the un-ionized ammonia standard for the Las Vegas Bay would have on the target concentrations and ultimately the TMDL/WLAs and permit limits. The study suggested that the target concentrations could be lowered considerably (0.32 mg/l – total phosphorus, 0.57 mg/l – total ammonia), representing a significant change in the TMDL. However the study also made it clear that additional work is needed to understand the dynamics of the Wash and Bay. Following completion of the 1994 study, NDEP decided that a revision of the TMDL/WLAs was not appropriate because of the uncertainties revealed by the study.

NDEP is in the process of reviewing the existing TMDL/WLAs to assess compliance and to determine if revisions are required. In 2002, UNLV completed a study entitled "Microbiological and Limnological Evaluations in the Las Vegas Wash/Bay System" to address some of the issues raised by the 1994 French report. NDEP's review will include an examination of the findings of the UNLV report. Another component of the TMDL review will include an evaluation of changes in flow conditions. During the years since the TMDL was developed, the average annual streamflow in the Las Vegas Wash has increased significantly while loading during the TMDL season (April through September) has not increased as required by the TMDL.

Truckee River: NDEP established TMDLs for TN, TP and TDS for the Truckee River in 1994. These TMDLs have been incorporated into the NPDES permit for the Truckee Meadows Water Reclamation Facility (TMWRF). During the mid-1990s, TMWRF was not able to consistently meet the waste load allocation (WLA) for total nitrogen due to a snail infestation of the nitrification towers. When the snails consume the bacterial populations down to low levels, the ammonia conversion to nitrates is severely diminished and nitrogen concentrations in the final effluent increases. Subsequent improvements have eliminated the problem and the plant has been able to meet its WLA requirements.

TMWRF is currently studying options for updating the TMDL. One possible revision could involve modifying the TN WLA to account for only the bioavailable portion of TN. The current TMDL assumes that all of the nitrogen in the TMWRF effluent is readily available for biological uptake. The goal of the study is to determine the degree to which the DON (dissolved organic nitrogen) in the TMWRF effluent is bioavailable. TMWRF is also studying the feasibility of reworking the TMDL/WLA so that higher winter TN loads would be acceptable during the winter months when less algal activity generally occurs.

Walker River: The existing TMDLs for total suspended solids (TSS) are included in Nevada's Nondesignated Areas 208 Plan (NDEP 1993). As with the Humboldt TMDLs, the existing Walker River TMDLs oversimplify a complex situation and do little to characterize sources to the level needed for a meaningful implementation plan. Additional work is needed to better identify sources in terms of their contributions and locations, and to better characterize beneficial use impairment (particularly aquatic life).

Other TMDL Activities

Bryant Creek: NDEP will be finalizing the Bryant Creek TMDL for metals in 2003.

East Fork Owyhee River: NDEP will be finalizing the East Fork Owyhee River TMDL for total phosphorus, total suspended solids, and iron in 2003

Lake Tahoe: NDEP is working inconjunction with the State of California (Lahontan Regional Water Quality Control Board) for the development of a Lake Tahoe TMDL to address clarity concerns caused by nutrient loading and fine sediments. It is anticipated that a technical TMDL will be completed in 2005, with subsequent implementation plan development by 2007..

Virgin River: NDEP will be finalizing the Virgin River TMDL for boron in 2003.

Statewide Observations

Nutrients

A relatively large number of waterbodies have been identified as impaired for total phosphorus (TP) throughout the state on both past and present 303(d) Lists. For many reaches, TP is the main or only parameter causing the waterbody to be listed as impaired. The standard of 0.1 mg/l (single value or annual average) applies across much of the state. This standard is based on recommendations made in EPA's "Quality Criteria for Water 1986" or commonly referred to as the Gold Book. These recommendations are not strongly supported in the Gold Book and are not identified as criteria, but rather as a "desired goal for the prevention of plant nuisances". Given the native soil conditions in the Great Basin and the topography that exists over much of Nevada, the suitability of the TP water quality standard must be questioned. It is clear that additional research is needed on the role of TP in eutrophication. Studies done on the Truckee River and Pyramid Lake have shown that, in fact, nitrogen rather than phosphorus is the limiting nutrient.

Another problem relates to the nitrogen standards set for various waterbodies in the state. In most cases, the nitrate standards are based upon drinking water standards rather than eutrophication control needs. As a result, current nitrate standards are likely higher than needed for controlling algae growth.

Before a large amount of resources are devoted to developing TMDLs and control strategies, it is advisable to evaluate the suitability of the existing water quality standards. In fact, Nevada is working with California, Arizona, Hawaii and EPA (Region 9) on the development of appropriate regional nutrient criteria.

Metals and Detection Limits

As discussed earlier, toxics concentrations in Nevada rivers are frequently less than the detection limits associated with the methods currently used by the State Health Laboratory for the NDEP monitoring program. This poses a problem when the detection limit is greater than the water quality criteria for the particular constituent. In those instances where the laboratory reports levels are "less than detection limit", it was not possible to determine whether or not a water quality standard is being met. For purposes of the 2002 303(d) List, it was generally assumed that a standard was being met if the data were reported as "less than the detection limit".

At this time, NDEP is working with the State Health Laboratory in lowering the detection limits thereby improving our ability to assess standards compliance. The constituents of particular concerns are summarized in Table 4 with the associated detection limits and water quality criteria for waters with a hardness of 30 mg/l as $CaCO_3$. In general, the lowest hardness levels found in Nevada's surface waters are around 30 mg/l. For those constituents with hardness-dependent criteria, the criteria become more restrictive with lower hardness values. It is at these lower hardness levels that the detection limits become a concern.

Table 4. Summary of Method Detection Limits and Criteria for Various Toxics

Parameter	Method Detection Limit, µg/l	1-hr Criteria, µg/l (for Hardness = 30 mg/l as $CaCO_3$)	96-hr Criteria, µg/l (for Hardness = 30 mg/l as $CaCO_3$)
Cadmium	1	0.9	0.4
Copper	20	4.9	3.6
Lead	2	8.8	0.2
Mercury	0.5	2	.012
Zinc	50	35.9	32.5

Note: Criteria are for dissolved concentrations, with the exception of mercury which is given as a total recoverable concentration. The mercury criteria are not hardness dependent.

Zinc

Exceedances of the dissolved zinc criteria were identified on a number of waterbodies. However upon close examination of the data, the dissolved zinc concentrations were found to be significantly greater than the total recoverable concentrations in many cases. This situation suggests that sample contamination may be occurring as it is not possible for dissolved concentrations to exceed total concentrations. Because of concerns about the accuracy of these data, no zinc listings were made using NDEP data.

Currently, NDEP is working with the State Health Laboratory to address this problem. It must be noted that this condition was found only with the zinc data and not other metals.

Truckee River Metals Monitoring

For several years, DRI (Desert Research Institute) has been monitoring water quality on the Truckee River. Due to funding constraints, metals analyses were dropped from the Truckee monitoring program in 1999. As a result, only 2 years of metals data were available for the

Truckee River monitoring sites for the period 1997-2001. Also, data were restricted to total recoverable concentrations with no dissolved concentration data.

Total Recoverable vs. Dissolved Concentrations (Metals)

Nevada's water quality standards for metals includes criteria for both total recoverable and dissolved concentrations. Until recently, NDEP monitoring data were available only for total recoverable levels. Beginning in 1998 and 1999 (depending on the waterbody), NDEP began collecting filtered samples. As a result, for many waterbodies less than 5 years of filtered data were available for comparison to the dissolved water quality criteria.

Arsenic

Nevada's current water quality standards for arsenic is 50 µg/l for municipal and domestic supply beneficial uses (NAC 445A.144). On January 22, 2001 EPA adopted a new MCL (maximum contaminant level) standard for arsenic in drinking water at 10 µg/l, replacing the old standard of 50 µg/l. The rule became effective on February 22, 2002 and drinking water supply systems have until January 23, 2006 to comply with the MCL. For the 2002 303(d) List, the Nevada's current water quality standard of 50 µg/l was utilized in the analyses. NDEP is in the process of reviewing and updating its toxics standards (including arsenic). It must be noted that the regulations state that surface water quality in support of the municipal/domestic supply beneficial use is to be of appropriate quality so that the water can be treated by conventional methods in order to comply with Nevada's drinking water standards. In other words, a waterbody with municipal/domestic supply as a beneficial use is not expected to meet the drinking water MCLs **without treatment.**

Fecal Coliform

For many waterbodies, the fecal coliform criteria reads as follows:

> " Based on a minimum of not less than 5 samples taken over a 30-day period, the fecal coliform bacterial level may not exceed a geometric mean of 200 per 100 ml nor may more than 10 percent of the total samples taken during any 30-day period exceed 400 per 100 ml."

There were no instances where the available data were of adequate frequency (at least 5 samples per month) to appropriately evaluate compliance with this standard. For instance, NDEP samples for bacteria 3 to 6 times per year depending upon the waterbody.

While the available fecal coliform data could not be used for assessing standards compliance and placing waters on the Impaired Waters List, the fecal coliform data were evaluated for possible inclusions on the "Potential Problems" list. For this analyses, the 200/100 ml standard was evaluated as an annual geometric mean standard, and the 400/100 ml standard was evaluated as a single value standard.

The existing fecal coliform criteria in the regulations were set for the prevention of illness resulting from water contact recreation. However, *E. Coli* bacteria has been found to be a better indicator of public health threats for water contact uses. Following U.S. EPA recommendations, NDEP is in the process of incorporating *E. Coli* criteria into the regulations.

pH

The 2002 303(d) List contains a number of waterbodies identified as impaired for pH. In some instances, the pH standards are outdated. Based upon EPA recommendations, the pH criteria for aquatic life propagation should be 6.5 to 9.0. NDEP is in the process of updating the appropriate pH criteria into the regulations.

Glossary

Best Management Practices (BMPs). Methods, measures, or practices determined to be reasonable and cost-effective means for a landowner to meet certain pollution (generally nonpoint source) control needs.

Geometric Mean. The value obtained by taking the "nth" root of the product of "n" numbers. Example: For the dataset (10, 15, 12, 11), the geometric mean = $(10 \times 15 \times 12 \times 11)^{1/4}$

Impaired waterbody. A water that does not attain/maintain the water quality standards throughout the waterbody due to individual or multiple pollutants or other causes of pollution.

Load allocations. The portion of a TMDL's pollutant load allocated to nonpoint sources (NPS) or background sources.

Median. For a given set of numbers, the median is the value which has an equal number of values greater and less than it.

Narrative standards. Nonquantitative guidelines that describe the desired water quality goals.

Nonpoint sources. Pollution that is discharged over a wide land area and not from one specific location.

Point sources. Pollutant loads discharge at a specific location from pipes, outfalls, and conveyance channels from either municipal wastewater treatment plants or industrial waste treatment facilities. This term does not include return flows from irrigated agriculture or agriculture storm water runoff.

Total Maximum Daily Load (TMDL). A TMDL is a written, quantitative plan and analysis for attaining and maintaining water quality standards in all seasons for a specific waterbody and pollutant. Total maximum daily loads or TMDLs are an assessment of the maximum amount of pollutant a waterbody can receive without violating water quality standards. TMDLs take into account pollution from all sources, including discharges from sewage treatment facilities and industry; runoff from farms, forests and urban areas; and natural sources. TMDLs provide a way to integrate the management of both point and nonpoint sources of pollution through the establishment of wasteload allocations (WLA) for point source discharges and load allocations (LA) for nonpoint sources of pollution. The TMDL Program is designed to help bring waterbodies into compliance with the water quality standards as needed to support their designated uses such as irrigation, aquatic life, municipal or domestic supply, and water contact recreation.

Waste load allocations. The portion of a TMDL's pollutant load allocated to point sources subject to NPDES permits.

Appendix A

Nevada's 2002 303(d) List

Table A-1. Nevada's 2002 303(d) List of Impaired Waterbodies

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Existing TMDLs	Pollutant or Stressor of Concern	Data Sources	TMDL Priority	New Listing?	Notes
Snake River Basin											
NV03-SR-02	445A.216	Salmon Falls Creek	Above stateline	37.2	miles	None	Iron (total)	NDEP	3	X	
							Temperature		3		
							Total phosphorus		3	X	
							Total suspended solids		3	X	
							Turbidity		3	X	
NV03-SR-03	445A.217	Shoshone Creek	Above stateline	11.51	miles	None	Iron (total)	NDEP	3	X	
							Temperature		3		
							Total phosphorus		3	X	
							Total suspended solids		3	X	
							Turbidity		3	X	
NV03-JR-12	445A.218	East Fork Jarbidge River	Above stateline	18.6	miles	None	Temperature	NDEP	3	X	
NV03-JR-13	445A.219	Jarbidge River	Source to Town of Jarbidge	7.44	miles	None	Total phosphorus	NDEP	3	X	
NV03-JR-14	445A.220	Jarbidge River	Town of Jarbidge to stateline	8.98	miles	None	Temperature	NDEP	3	X	
NV03-OW-18	445A.222	East Fork Owyhee River	Wildhorse Reservoir to Mill Creek	13.75	miles	Draft TMDL Iron, Total phosphorus, TDS, TSS, turbidity	Iron (total)	NDEP	1		
							Temperature		3	X	
							Total phosphorus		1		
							Total suspended solids		1		
							Turbidity		1		
NV03-OW-19	445A.223	East Fork Owyhee River	Mill Creek to Duck Valley Indian Reservation	7.71	miles	Draft TMDL Iron, Total phosphorus, TDS, TSS, turbidity	Total phosphorus	NDEP	1		3
							Total suspended solids		1		3
							Turbidity		1		3
NV03-OW-25-B	445A.125	Wildhorse Reservoir	Entire Reservoir	2,830	Acres	None	pH	NDEP	3	X	4
							Temperature		3	X	5
							Total phosphorus		3	X	6
NV03-OW-27	445A.225	South Fork Owyhee River	Above Stateline	75	miles	None	Temperature	BLM - Elko District	3	X	
NV03-OW-100	Tributary to SF Owyhee River - 445A.225	Snow Creek	Below Jerritt Canyon Project	6	miles	None	Total dissolved solids	AngloGold-Meridian Jerritt Canyon Joint Venture	3	X	
NV03-OW-101	Tributary to SF Owyhee River - 445A.225	Jerritt Canyon Creek	Below Jerritt Canyon Project	6	miles	None	Total dissolved solids	AngloGold-Meridian Jerritt Canyon Joint Venture	3	X	
NV03-OW-102	Tributary to SF Owyhee River - 445A.225	Mill Creek	Below Jerritt Canyon Project	1	miles	None	Total dissolved solids	AngloGold-Meridian Jerritt Canyon Joint Venture	3	X	

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Table A-1. Nevada's 2002 303(d) List of Impaired Waterbodies (continued)

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Existing TMDLs	Pollutant or Stressor of Concern	Data Sources	TMDL Priority	New Listing?	Notes
Snake River Basin											
NV03-OW-34-C	Tributary to EF Owyhee River - 445A.223	Mill Creek	Above East Fork Owyhee River	1.44	miles	Draft TMDL Iron, Total phosphorus, TDS, TSS	Cadmium (total)	NDEP	3	X	
							Copper (total & dissolved)		3	X	8
							Dissolved oxygen		3	X	
							Iron (total)		1	X	
							pH		3	X	
							Temperature		3	X	
							Total dissolved solids		1	X	
							Total phosphorus		1	X	6
							Total suspended solids		1	X	
							Turbidity		3	X	
Humbolt River Basin											
NV04-HR-01	445A.203	Humboldt River	Origin to Osino	66.12	miles	none	Iron (total)	NDEP	2	X	7
							Total phosphorus		2	X	6
NV04-HR-02	445A.204	Humboldt River	Osino to Palisade	64.39	miles	Total phosphorus, TSS	Iron (total)	NDEP	2		
							Total phosphorus		2		6
							Turbidity		2		
NV04-HR-03	445A.205	Humboldt River	Palisade to Battle Mtn	76.5	miles	Total phosphorus, TSS	Iron (total)	NDEP	3		3
							Total phosphorus		3		6
							Total suspended solids		3	X	
							Turbidity		3		
NV04-HR-04	445A.206	Humboldt River	Battle Mtn to Comus	81.36	miles	Total phosphorus, TDS, TSS	Boron (total)	NDEP	3	X	
							Iron (total)		3		
							Total dissolved solids		3	X	
							Total phosphorus		3		6
							Total suspended solids		3	X	
							Turbidity		3		
NV04-HR-05	445A.207	Humboldt River	Comus to Imlay	114.09	miles	Total phosphorus, TDS, TSS	Iron (total)	NDEP	3		3,7
							Total dissolved solids		3	X	
							Total phosphorus		3		6
							Total suspended solids		3	X	
							Turbidity		3		
NV04-HR-06	445A.208	Humboldt River	Imlay to Woolsey	44.42	miles	None	Molybdenum	USGS	3	X	

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Table A-1. Nevada's 2002 303(d) List of Impaired Waterbodies (continued)

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Existing TMDLs	Pollutant or Stressor of Concern	Data Sources	TMDL Priority	New Listing?	Notes
Humboldt River Basin											
NV04-HR-07-C	445A.126	Humboldt River	Woolsey to Rodgers Dam	13.22	miles	None	pH	NDEP	3	X	7, 9
							Total dissolved solids		3	X	7
NV04-HR-08-D-01	445A.127	Humboldt River/Sink	Rodgers Dam to Humboldt Sink	22.77	miles	None	Boron (total)	NDEP, USGS	3		
							Iron (total)	NDEP	3		
NV04-HR-08-D-02			Humboldt Sink	12,000	acres		Molybdenum	USGS	3	X	
NV04-MR-10-B	445A.125	Mary's River	East line of T41N, R59E to Humboldt River	53.2	miles	None	Total phosphorus	NDEP	3	X	6
NV04-NF-16-A	445A.124	North Fork Humboldt River and its tributaries in the Independence Mountain Range (specifically Dry Creek, Sammy Creek, Water Canyon Creek	NF Humboldt - Confluence with Sammy Creek to National Forest Boundary	3.5	miles	None	Selenium (total)	AngloGold Corporation, USFWS	3	X	1
							Total dissolved solids		3	X	
			Dry Creek - waste rock to confluence with NF Humboldt	0.1	miles	None	Selenium (total)		3	X	8
							Total dissolved solids		3	X	
			Sammy Creek - above waste rock	0.6	miles	None	Arsenic (total)		3	X	
							Selenium (total)		3	X	8
			Sammy Creek - waste rock to confluence with NF Humboldt	0.6	miles	None	Selenium (total)		3	X	1
							Total dissolved solids		3	X	
			Water Canyon Creek - waste rock to confluence with NF Humboldt	0.3	miles	None	Selenium (total)		3	X	8
							Total dissolved solids		3	X	
NV04-NF-17-B	445A.125	North Fork Humboldt River	National Forest Boundary to Humboldt River	84.67	miles	None	Iron (total)	NDEP	3	X	7
							pH		3	X	9
							Temperature		3	X	
							Total phosphorus		3	X	6
NV04-SF-19-B-01	445A.125	South Fork Humboldt River	Lee to Humboldt River	32.75	miles	None	Iron (total)	NDEP	3	X	
							pH		3	X	9
							Total phosphorus		3	X	6
NV04-SF-19-B-02	445A.125	South Fork Humboldt Reservoir	Entire Reservoir	1,650	acres	None	pH	NDEP	3	X	4
							Temperature		3	X	5
NV04-HR-26-B	445A.125	Maggie Creek	Where it is formed by tributaries to confluence with Jack Creek	28.07	miles	None	Total phosphorus	NDEP	3	X	6, 7

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Table A-1. Nevada's 2002 303(d) List of Impaired Waterbodies (continued)

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Existing TMDLs	Pollutant or Stressor of Concern	Data Sources	TMDL Priority	New Listing?	Notes
Humbolt River Basin											
NV04-HR-27-C	445A.126	Maggie Creek	Confluence with Jack Creek to Humboldt River	23.74	miles	None	pH	NDEP, Newmont Mining Corporation	3	X	4
NV04-LH-47-C	445A.126	Little Humboldt River	Entire Length	53.52	miles	None	Total phosphorus	NDEP	3	X	7
NV04-HR-56-C	Tributary to Humboldt River - 445A.205	Pine Creek	Upstream of Palisade	15.92	miles	None	Iron (total)	NDEP	3	X	7
							pH		3	X	9
							Total dissolved solids		3	X	
							Total phosphorus		3	X	6
							Total suspended solids		3	X	
							Turbidity		3	X	
NV04-HR-100-C	Tributary to Maggie Creek - 445A.126	Simon Creek	Above confluence with Maggie Creek	1	miles	None	Total dissolved solids	Newmont Mining Corporation	3	X	
NV04-HR-101	Tributary to Pine Creek & Humboldt River - 445A.205	Willow Creek	Below Buckhorn Mine	5	miles	None	Mercury (dissolved)	Cominco American Inc.	3	X	
NV-04-HR-102-B	Tributary to North Fork Humboldt River - 445A.125	Sheep Creek	Below Jerritt Canyon Project	6	miles	None	Total dissolved solids	AngloGold-Meridian Jerritt Canyon Joint Venture	3	X	
Lake Tahoe Basin											
NV06-TB-08	445A.191	Lake Tahoe	At Cave Rock Monitoring Site	36,812 (Nevada portion only)	acres	TMDL underdevelopment	DO - % of saturation	NDEP	3	X	5
							Temperature		3	X	5
			At Sand Harbor Monitoring Site				Specific electrical conductance		3	X	5
							Total nitrogen		3		5
			Mid-Lake and Index Station				Clarity	Tahoe Research Group Data	1	X	
NV06-TB-10-01	445A.1915	2nd Creek	2nd Creek Drive to Lake Tahoe	0.45	miles	None	Total phosphorus	NDEP	3	X	
							Turbidity		3	X	
NV06-TB-10-02	445A.1915	2nd Creek	Origin to 2nd Creek Drive	2	miles	None	Total phosphorus	NDEP	3	X	
									3		

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Table 1. Nevada's 2002 303(d) List of Impaired Waterbodies (continued)

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Existing TMDLs	Pollutant or Stressor of Concern	Data Sources	TMDL Priority	New Listing?	Notes
Lake Tahoe Basin											
NV06-TB-12	445A.1915	3rd Creek	Lake Tahoe to EF 3rd Creek at Highway 431 and to WF 3rd Creek Origin	0.31	miles	None	Total phosphorus	NDEP	3	X	
NV06-TB-15	445A.1915	EF Incline Creek	Ski resort to Origin	4.66	miles	None	Total phosphorus	NDEP	3	X	
NV06-TB-16	445A.1915	Incline Creek	Lake Tahoe to EF Incline Creek at ski resort and to WF Incline Creek at Highway 431	0.19	miles	None	Iron (total)	NDEP	3	X	
NV06-TB-26	445A.1915	Glenbrook Creek	Above Lake Tahoe	3.83	miles	None	Iron (total)	USGS	3	X	
							Total phosphorus		3	X	
NV06-TB-33	445A.1915	Edgewood Creek	Above Lake Tahoe	5.37	miles	None	Iron (total)	USGS	3	X	
Truckee River Basin											
NV06-TR-03	445A.186	Truckee River	Idlewild to East McCarran	6.25	miles	None	Temperature	TMWRF	3	X	
NV06-TR-04	445A.187	Truckee River	East McCarran to Lockwood	5.85	miles	Total nitrogen, total phosphorus, TDS	Total phosphorus	DRI/TMWRF	3		6
NV06-TR-05	445A.188	Truckee River	Lockwood to Derby Dam	15.15	miles	Total nitrogen, total phosphorus, TDS	Total phosphorus	DRI/TMWRF	3		6
							Turbidity		3		
NV06-TR-06	445A.189	Truckee River	Derby Dam to Pyramid Lake Reservation	11.22	miles		Temperature	DRI/TMWRF	3	X	
							Total phosphorus		3		6
							Turbidity		3		
NV06-SC-41-C	445A.126	Steamboat Creek	Washoe Lakes to Sec 33, T18N, R20E	5.41	miles	None	Iron (total)	NDEP	3	X	
							pH		3	X	9
							Mercury (total)	NDEP, UNR	3	X	2
							Total phosphorus	NDEP	3	X	
NV06-SC-42-D	445A.127	Steamboat Creek	Sec 33, T18N, R20E to Truckee River	13.71	miles	None	Arsenic (total)	NDEP	3	X	
							Boron (total)		3	X	
							Iron (total)		3	X	
							Mercury (total)	NDEP, UNR	3	X	2
NV06-SC-45-B	445A.125	Franktown Creek	First irrigation diversion to Washoe Lake	9.07	miles	None	Dissolved oxygen	NDEP	3	X	

Table A-1. Nevada's 2002 303(d) List of Impaired Waterbodies (continued)

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Existing TMDLs	Pollutant or Stressor of Concern	Data Sources	TMDL Priority	New Listing?	Notes
Truckee River Basin											
NV06-SC-52-C	445A.126	Galena Creek	Sec 2, T17N, R19E to Steamboat Creek	3.63	miles	None	pH	NDEP	3	X	9
NV06-SC-53-A	445A.124	Whites Creek	Source to east line of Sec 33, T18N, R19E	8.83	miles	None	pH	NDEP	3	X	9
NV06-SC-55-A	445A.124	Thomas Creek	Source to National Forest Boundary	4.34	miles	None	pH	NDEP	3	X	9
Carson River Basin											
NV08-CR-02	445A.148	Bryant Creek	Near Stateline	0	miles	Draft TMDL Copper, Iron, Nickel	Arsenic (total)	NDEP	3	X	
							Copper	Leviathan Mine Database	1		3, 10
							Iron (total)	NDEP	1		
							Nickel	Leviathan Mine Database	1		3, 10
							Temperature	NDEP	3	X	
							Total suspended solids		3	X	
							Turbidity		3	X	
NV08-CR-04	445A.150	EF Carson River	Stateline to Highway 395	10.48	miles	BOD, Nitrate, Phosphates, TDS	Iron (total)	NDEP	3	X	
							Turbidity		2		
NV08-CR-05-01	445A.151	EF Carson River	Highway 395 to Highway 88	8.53	miles	BOD, Nitrate, Phosphates, TDS	Temperature	NDEP	3	X	
							Turbidity		2		
NV08-CR-05-02			Highway 88 to Muller Lane	2	miles	BOD, Nitrate, Phosphates, TDS	Iron (total)	NDEP	3	X	
							Temperature		3	X	
							Total phosphorus		2	X	
							Turbidity		2		
NV08-CR-06-01	445A.152	WF Carson River	Stateline to Muller Lane	11.23	miles	BOD, Nitrate, Phosphates, TDS	Iron (total)	NDEP	3	X	
							Temperature		3	X	
							Total phosphorus		2		6
							Turbidity		2		
NV08-CR-06-02		EF/WF Carson River	Genoa Lane to EF Carson River at Muller Lane and to WF Carson River at Muller Lane	4.59	miles	BOD, Nitrate, Phosphates, TDS	Iron (total)	NDEP	3	X	
							Temperature		3	X	
							Total phosphorus		2		6
							Total suspended solids		2	X	
							Turbidity		2		

Table A-1. Nevada's 2002 303(d) List of Impaired Waterbodies (continued)

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Existing TMDLs	Pollutant or Stressor of Concern	Data Sources	TMDL Priority	New Listing?	Notes
Carson River Basin											
NV08-CR-07	445A.153	Carson River	Genoa Lane to Cradlebaugh Bridge	5.88	miles	BOD, Nitrate, Phosphates, TDS	Iron (total)	NDEP	3	X	
							Temperature		3	X	
							Total phosphorus		2		6
							Total suspended solids		2	X	
							Turbidity		2		
NV08-CR-08	445A.154	Carson River	Cradlebaugh Bridge to Mexican Ditch Gage	6.34	miles	BOD, Nitrate, Phosphates, TDS	Iron (total)	NDEP	3	X	
							Temperature		3	X	
							Total phosphorus		2		6
							Total suspended solids		2	X	
							Turbidity		2		
NV08-CR-09	445A.155	Carson River	Mexican Ditch Gage to New Empire	7.82	miles	BOD, Nitrate, Phosphates, TDS	Iron (total)	NDEP	3	X	
							Temperature		3	X	
							Total phosphorus		2		6
							Turbidity		2		
NV08-CR-10	445A.156	Carson River	New Empire to Dayton Bridge	16.82	miles	BOD, Nitrate, Phosphates, TDS	Iron (total)	NDEP	3	X	
							Mercury (total)	NDEP	3		2, 11, 12
							Total phosphorus	NDEP	1		6
							Total suspended solids		1	X	
NV08-CR-11	445A.157	Carson River	Dayton Bridge to Weeks	25.5	miles	BOD, Nitrate, Phosphates, TDS	Iron (total)	NDEP	3	X	
							Mercury (total)	NDEP	3		2, 11, 12
							Total phosphorus	NDEP	1		6
							Total suspended solids		1	X	
							Turbidity		1	X	
NV08-CR-12	445A.158	Carson River	Weeks to Lahontan Dam	29.17	miles	BOD, Nitrate, Phosphates, TDS	Iron (total)	NDEP	3		7
							Mercury (total)	NDEP	3		2, 11, 12
							pH		3	X	9
							Total phosphorus	NDEP	3		6
							Total suspended solids		3		
							Turbidity		3	X	
NV08-CR-13-C	445A.126	Carson River	Lahontan Reservoir to Carson Sink	40.46	miles	None	Mercury	NDEP	3	X	11, 12
NV08-CR-17-A	445A.124	Clear Creek	Origin to Gaging Station in Sec. 1, T14N, R19E	7.98	miles	None	pH	NDEP	3	X	9

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Table A-1. Nevada's 2002 303(d) List of Impaired Waterbodies (continued)

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Existing TMDLs	Pollutant or Stressor of Concern	Data Sources	TMDL Priority	New Listing?	Notes
Carson River Basin											
NV08-CR-27-C	445A.126	Stillwater Marsh	Area of Stillwater Marsh east of Westside Road and north of the community of Stillwater	19,326 (Class C and Class D waters)	acres	None	Arsenic	NDEP	3		
							Boron		3		
							Mercury		3		12
NV08-CR-100	Tributary to Carson River - 445A.153	Brockliss Slough	Above Carson River	5	miles	None	Iron (total)	NDEP	3	X	14
							Temperature		3	X	14
							Total phosphorus		3	X	6, 14
							Turbidity		3	X	14
NV08-CR-101	Tributary to Carson River - 445A.151	Indian Creek	At Stateline	0	miles	None	Total phosphorus	South Tahoe Public Utilities District	3	X	
Various	Not applicable	All waters below Lahontan Dam in Lahontan Valley	n/a	n/a	n/a	None	Mercury	NDEP, NDOW, Nevada Health Division	3	X	12
Walker River Basin											
NV09-WR-01	445A.160	West Walker River	At Stateline	0	miles	None	Iron (total)	NDEP	3	X	
							Total phosphorus		3	X	6
NV09-WR-02	445A.161	Topaz Lake	Topaz Lake (Nevada portion)	988	acres	None	Temperature		3	X	5
NV09-WR-03	445A.162	West Walker River	Stateline to Wellington	16.9	miles	None	Boron (total)	NDEP	3	X	
							Iron (total)		3	X	
							pH		3		
							Total phosphorus		3		6
NV09-WR-04	445A.163	West Walker River	Wellington to Confluence with East Walker River	25.69	miles	None	E Coli	NDEP	3	X	
							Iron (total)		3	X	7
							Total phosphorus		3		6
NV09-WR-05	445A.164	Sweetwater Creek	Stateline to Confluence with East Walker River	8.07	miles	None	E Coli	NDEP	3	X	
							Total phosphorus		3		6
NV09-WR-06	445A.165	East Walker River	At Stateline	0	miles	None	Ammonia (unionized)	NDEP	3	X	
							Nitrite		3	X	
							pH		3		
							Temperature		3	X	
							Total phosphorus		3		6
NV09-WR-07	445A.166	East Walker River	Stateline to Bridge B-1475	22.7	miles	Total suspended solids	pH	NDEP	3	X	
							Total phosphorus		3	X	6

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Table A-1. Nevada's 2002 303(d) List of Impaired Waterbodies (continued)

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Existing TMDLs	Pollutant or Stressor of Concern	Data Sources	TMDL Priority	New Listing?	Notes
Walker River Basin											
NV09-WR-08	445A.166	East Walker River	East Walker River from Bridge B-1475 to the confluence with the W. Walker	41.7	miles	Total suspended solids	Iron (total)	NDEP	3		3
							Temperature		3	X	
							Total phosphorus		3	X	6
							Total suspended solids		3		
NV09-WR-09	445A.167	Walker River	Confluence of East and West Walker Rivers to Walker River Indian Reservation Boundary	41.15	miles	Total suspended solids	Iron (total)	NDEP	3		
							Total suspended solids		3		
NV09-WR-11	To be assigned	Walker Lake	Entire Reservoir	35,500	acres	None	Total dissolved solids	NDEP, NDOW, USFWS, UC Berkeley, others	1	X	13
NV09-WR-12	445A.169	Desert Creek	Stateline to Confluence with West Walker River	23.39	miles	None	Temperature	NDEP	3	X	
NV-09-WR-13-C	445A.126	Mason Valley Wildlife Management Area (North Pond only)	North Pond	100	acres	None	pH	NDEP	3	X	4
							Total dissolved solids		3	X	
							Total phosphorus		3	X	6
Central Region											
NV10-CE-33-C	445A.126	Comins Lake	Entire Lake	136	acres	None	pH	NDEP	3	X	4
							Temperature		3	X	5
Colorado River Basin											
NV13-CL-01	445A.192	Colorado River	Lake Mohave Inlet to CA stateline	60.94	miles	None	pH	NDEP	3	X	9
							Temperature		3	X	5
NV13-CL-02	445A.191	Colorado River	Hoover Dam to Lake Mohave inlet	31.27	miles	None	pH	NDEP	3	X	9
							Temperature		3	X	5
NV13-CL-06	445A.201	Las Vegas Wash	Telephone Line Road to Lake Mead	5.12	miles	Total ammonia, total phosphorus	Iron (total)	NDEP	3	X	
							Total suspended solids	NDEP, Wash Discharger Monitoring Network	3	X	
NV13-CL-07	445A.175	Virgin River	Stateline to Mesquite	4.5	miles	Draft TMDL Boron	Boron (total)	NDEP	1		
							Iron (total)		3	X	
							Temperature		3	X	
							Total phosphorus		3		6

Table A-1. Nevada's 2002 303(d) List of Impaired Waterbodies (continued)

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Existing TMDLs	Pollutant or Stressor of Concern	Data Sources	TMDL Priority	New Listing?	Notes
Colorado River Basin											
NV13-CL-09	445A.177	Virgin River	Mesquite to Lake Mead	25.75	miles	Draft TMDL Boron	Boron (total)	NDEP	1		
							Iron (total)		3	X	
							Temperature		3	X	
							Total phosphorus		3		6
NV13-CL-11	445A.210	Muddy River	Source to Glendale	13.63	miles	None	Iron (total)	NDEP	3		
							Temperature		3	X	
							Total phosphorus		3		6
NV13-CL-12	445A.211	Muddy River	Glendale to Lake Mead	25.07	miles	None	Boron (total)	NDEP	3		
							Iron (total)		3	X	
							Temperature		3	X	
NV13-CL-25-C	445A.126	Echo Canyon Reservoir	Entire reservoir	58	acres	None	pH	NDEP	3	X	4, 7
							Temperature		3	X	5, 7

Footnotes:

1. The 1-hour criteria were not exceeded, but the 96-hour criteria was exceeded in over 10% of the samples. Selenium levels in Lahontan cutthroat trout sampled by the US Fish and Wildlife Service in 1998 exceeded the toxicity threshold presented in "Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment", National Irrigation Water Quality Program Information Report No. 3, November 1998.

2. The 1-hour criteria were not exceeded, but the 96-hour criteria were exceeded in over 10% of the samples. Though grab samples may not representative of conditions (depending upon the situation) over a 96-hour period, the fact that the grab sample data consistently exceeded the 96-hour criteria by a factor of 50 to 100 times the standard is deemed to be a good indication that the 96-hour conditions are in fact in exceedance of the 96-hour standard.

3. Less than 10 samples were available at the control point for this parameter, however this parameter was on the 1998 303(d) List and the available data does not justify delisting.

4. Current pH standard is outdated and needs to be revised to 6.5 to 9.0 based upon current EPA recommendations. However, the available data show that the new pH criteria have not be met.

5. Sampling point may not be representative of conditions for this parameter.

6. The phosphorus standard may not be appropriate for eutrophication control.

7. 8 to 9 samples were available at the control point for this parameter, however there were significant exceedances (4 or more) in the available samples.

8. Both the 1-hour and 96-hour criteria were exceeded in over 10% of the samples.

9. Current pH standard is outdated and needs to be revised to 6.5 to 9.0 based upon current EPA recommendations. The available data show that the new pH criteria will be met.

10. Leviathan Mine is listed on the National Priorities List (Superfund) because of acid mine drainage into adjoining creeks. Copper, iron and nickel have been found to be present in amounts that are harmful to public health, the environment and aquatic life.

11. Carson River from New Empire down to Carson Sink is listed on the National Priorities List (Superfund) due to mercury contamination from historic mining activities.

12. Nevada State Health Division has issued a fish consumption advisory for the Carson River from Dayton to Lahontan Dam and all waters in the Lahontan Valley.

13. In 2002, EPA approved the beneficial uses and criteria promulgated by the State of Nevada for Walker Lake. The propagation of aquatic life was included as one of the beneficial uses. While the standards do not include numeric criteria for TDS, the Nevada Division of Wildlife has shown that TDS levels have impaired the aquatic life beneficial use. NDOW found that hatchery Lahontan Cutthroat Trout experienced high death rates upon release into the high TDS waters of Walker Lake. In the mid-1990s, the Nevada Division of Wildlife began acclimating the hatchery trout in high TDS water prior to releasing into Walker Lake. While this acclimation process has improved initial fish survival, the health and lifespan of the LCT and its food sources are impaired due to the elevated TDS levels. Increasing TDS concentrations have caused significant biological changes in Walker Lake, including a reduction in biological diversity and the extinction of at least one zooplankton species. Additionally, the 2002 305(b) Report identified Walker Lake as "Not Supporting".

14. While the Brockliss Slough has no specific numeric criteria, the tributary rule was applied thereby utilizing the numeric criteria for the Carson River: Genoa to Cradlebaugh Bridge Reach (NAC 445A.153). It needs to be recognized that at the junction of Brockliss Slough and the West Fork Carson River most of the West Fork Carson River flow enters the Brockliss Slough, with little flow continuing down the West Fork channel at this point.

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Appendix B

List of Waterbodies with Exceedances of RMHQs (Requirements to Maintain Higher Quality Water)

Table B-1. List of Waterbodies with Exceedances of RMHQs (Requirements to Maintain Higher Quality Water)

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Pollutant or Stressor of Concern	Notes
Snake River Basin							
NV03-SR-02	445A.216	Salmon Falls Creek	Above stateline	37.2	miles	Fecal coliform	
NV03-JR-12	445A.218	East Fork Jarbidge River	Above stateline	18.6	miles	Fecal coliform	
NV03-JR-13	445A.219	Jarbidge River	Source to Town of Jarbidge	7.44	miles	Total phosphorus	
Humbolt River Basin							
NV04-HR-01	445A.203	Humboldt River	Origin to Osino	66.12	miles	pH	
NV04-HR-02	445A.204	Humboldt River	Osino to Palisade	64.39	miles	Chlorides	
						pH	
NV04-HR-03	445A.205	Humboldt River	Palisade to Battle Mtn	76.5	miles	pH	
NV04-HR-04	445A.206	Humboldt River	Battle Mtn to Comus	81.36	miles	Chlorides	
						pH	
						Total dissolved solids	
NV04-HR-05	445A.207	Humboldt River	Comus to Imlay	114.09	miles	Chlorides	
						pH	
NV04-HR-06	445A.208	Humboldt River	Imlay to Woosley	44.42	miles	Total dissolved solids	
Lake Tahoe Basin							
NV06-TB-09-00	445A.1917	1st Creek	Origin to Lake Tahoe	1.8	miles	pH	
						Total nitrogen	
NV06-TB-10-01	445A.1917	2nd Creek	2nd Creek Drive to Lake Tahoe	0.45	miles	pH	
						Total nitrogen	
NV06-TB-10-02	445A.1917	2nd Creek	Origin to 2nd Creek Drive	2	miles	pH	
						Total nitrogen	
NV06-TB-12	445A.1917	3rd Creek	Lake Tahoe to EF 3rd Creek at Highway 431 and to WF 3rd Creek Origin	0.31	miles	Chlorides	
						Total dissolved solids	

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Table B-1. List of Waterbodies with Exceedances of RMHQs (Requirements to Maintain Higher Quality Water) (continued)

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Pollutant or Stressor of Concern	Notes
Lake Tahoe Basin							
NV06-TB-14	445A.1917	WF Incline Creek	Origin to Highway 431	3.11	miles	Chlorides	
						pH	
						Total dissolved solids	
						Total nitrogen	
						Turbidity	
NV06-TB-15	445A.1917	EF Incline Creek	Ski resort to Origin	4.66	miles	pH	
						Total nitrogen	
NV06-TB-16	445A.1917	Incline Creek	Lake Tahoe to EF Incline Creek at ski resort and to WF Incline Creek at Highway 431	0.19	miles	Chlorides	
						pH	
						Total nitrogen	
Truckee River Basin							
NV06-TR-02	445A.185	Truckee River	Stateline to Idlewild	15.7	miles	Total nitrogen	
NV06-TR-03	445A.186	Truckee River	Idlewild to East McCarran	6.25	miles	Total nitrogen	
NV06-TR-04	445A.187	Truckee River	East McCarran to Lockwood	5.85	miles	Total phosphorus	
NV06-TR-05	445A.188	Truckee River	Lockwood to Derby Dam	15.15	miles	Turbidity	
Carson River Basin							
NV08-CR-01	445A.147	WF Carson River	At Stateline	0	miles	pH	
						Total nitrogen	
						Total phosphorus	
NV08-CR-02	445A.148	Bryant Creek	Near Stateline	0	miles	Total nitrogen	
						Total phosphorus	
NV08-CR-04	445A.150	EF Carson River	Stateline to Highway 395	10.48	miles	pH	
						Total dissolved solids	
						Total nitrogen	

Table B-1. List of Waterbodies with Exceedances of RMHQs (Requirements to Maintain Higher Quality Water) (continued)

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Pollutant or Stressor of Concern	Notes
Carson River Basin							
NV08-CR-05	445A.151	EF Carson River	Highway 395 to Muller Lane	10.53	miles	pH	
						Total nitrogen	
NV08-CR-06	445A.152	EF/WF Carson River	Genoa Lane to EF Carson River at Muller Lane and to WF Carson River at Stateline	15.82	miles	pH	
						Total dissolved solids	
NV08-CR-07	445A.153	Carson River	Genoa Lane to Cradlebaugh Bridge	5.88	miles	Chlorides	
						pH	
						Total dissolved solids	
NV08-CR-08	445A.154	Carson River	Cradlebaugh Bridge to Mexican Ditch Gage	6.34	miles	Sulfate	
NV08-CR-09	445A.155	Carson River	Mexican Ditch Gage to New Empire	7.82	miles	pH	
NV08-CR-10	445A.156	Carson River	New Empire to Dayton Bridge	16.82	miles	Chlorides	
						pH	
						Turbidity	
NV08-CR-11	445A.157	Carson River	Dayton Bridge to Weeks	25.5	miles	Chlorides	
						Fecal coliform	
						pH	
						Turbidity	
NV08-CR-12	445A.158	Carson River	Weeks to Lahontan Dam	29.17	miles	Chlorides	
						Total dissolved solids	
						Turbidity	
Walker River Basin							
NV09-WR-01	445A.160	West Walker River	At Stateline	0	miles	Total suspended solids	
NV09-WR-02	445A.161	Topaz Lake	Topaz Lake (Nevada portion)	988	acres	Total nitrogen	
						Total suspended solids	
						Turbidity	

Table B-1. List of Waterbodies with Exceedances of RMHQs (Requirements to Maintain Higher Quality Water) (continued)

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Pollutant or Stressor of Concern	Notes
Walker River Basin							
NV09-WR-03	445A.162	West Walker River	Stateline to Wellington	16.9	miles	Chlorides	
						Total dissolved solids	
						Total nitrogen	
						Total phosphorus	
NV09-WR-04	445A.163	West Walker River	Wellington to Confluence with East Walker River	25.7	miles	Chlorides	
						Total phosphorus	
NV09-WR-05	445A.164	Sweetwater Creek	Stateline to Confluence with East Walker River	8.07	miles	Total nitrates	
NV09-WR-06	445A.165	East Walker River	At Stateline	0	miles	Total nitrogen	
NV09-WR-08	445A.166	East Walker River	East Walker River from Bridge B-1475 to the confluence with the W. Walker	41.7	miles	Sulfate	
Colorado River Basin							
NV13-CL-04	445A.195	Lake Mead/Las Vegas Bay	Las Vegas Bay	3,840	acres	chlorophyll a	1
						Total inorganic nitrogen	2
NV13-CL-07	445A.175	Virgin River	Stateline to Mesquite	4.5	miles	Total nitrogen	

Notes:

Except as noted in the following, all data for identifying RMHQ exceedances were taken from NDEP ambient monitoring program. including Truckee River monitoring performed by Desert Research Institute and Truckee Meadows Wastewater Reclamation Facility.

1. Chlorophyll a exceeded more than 10% of samples at Stations LM4 (LVB2.7) and LM5 (LVB3.5). Based upon data collected by Las Vegas Wash Discharger Monitoring Network.
2. Total inorganic nitrogen exceeded more than 10% of samples at Stations LM2 (LVB1.8) and LM3 (LVB1.85). Based upon data collected by Las Vegas Wash Discharger Monitoring Network.

Appendix C

List of Waterbodies with Potential Problems

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Table C-1. List of Waterbodies with Potential Problems

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Pollutant or Stressor of Concern	Data Sources	Notes
Black Rock Desert Region						
NV02-BL-09-B	445A.125	Bilk Creek Reservoir	Entire Reservoir	Dissolved oxygen	NDEP	1
				pH		2
				Total phosphorus		3
NV02-BL-100	445A.121	Charleston Gulch	Below National Mine site	Metals	NDEP	
				pH		
NV02-BL-101	445A.121	National Gulch	Below National Mine site	Metals	NDEP, USGS Open File Report 00-459	
				pH		
Snake River Basin						
NV03-OW-19	445A.223	East Fork Owyhee River	Mill Creek to Duck Valley Indian Reservation .	Copper (dissolved)	NDEP	
				Iron (total)		
Humbolt River Basin						
NV04-HR-07-C	445A.126	Humboldt River	Woolsey to Rodgers Dam	Iron (total)	NDEP	
NV04-HR-26-B	445A.125	Maggie Creek	Where it is formed by tributaries to confluence with Jack Creek	Temperature	NDEP	
NV04-HR-33-C	445A.126	Rock Creek	Below Squaw Valley Ranch	pH	NDEP	4
NV04-RR-38-B	445A.125	Reese River	Confluence with Indian Creek to old Highway 50	pH	NDEP	4
				Total dissolved solids		
NV04-RR-39-C	445A.126	Reese River	North of old Highway 50	Total dissolved solids	NDEP	
				Total phosphorus		3
NV04-LH-45-A	445A.124	North Fork Little Humboldt River	Below Buckskin Mine site to forest boundary	Metals	NDEP, USFS	
				pH		
NV04-LH-47-C	445A.126	Little Humboldt River	Entire length	Dissolved oxygen	NDEP	
				Iron (total)		
				pH		4
				Temperature		
NV04-LH-49-B	445A.125	South Fork Little Humboldt River	Elko/Humboldt County Line to confluence with North Fork Little Humboldt River	Iron (total)	NDEP	
				pH		4
				Total phosphorus		3
NV04-HR-55-B	Tributary to Humboldt River -445A.205	Pine Creek	Above Tomera Ranch	E coli	NDEP	
				Iron (total)		
				Total dissolved solids		
				Total phosphorus		3
				Total suspended solids		
				Turbidity		

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Table C-1. List of Waterbodies with Potential Problems (continued)

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Pollutant or Stressor of Concern	Data Sources	Notes
Humbolt River Basin						
NV04-HR-101	Tributary to Pine Creek and Humboldt River - 445A.205	Willow Creek	Below Buckhorn Mine	Cyanide	Cominco American, Inc.	8
NV04-HR-103-A	Tributary to Maggie Creek - 445A.124	Coon Creek	Below Rip Van Winkle Mine	Acid mine drainage	Interagency AML Environmental Task Force, USGS Open File Report 00-459	
NV04-HR-104-A	Tributary to South Fork Humboldt River - 445A.124	Long Canyon Creek (near Lamoille)	Below American Beauty Mine	Metals	EPA-REMAP	
NV04-HR-105	445A.121	Long Canyon Creek (near Battle Mtn.)	Below historic mine site	Metals	USGS Open File Report 00-459; BLM Battle Mountain District	
NV04-HR-106	445A.121	Licking Creek (near Battle Mtn.)	Below historic mine site	Metals	USGS Open File Report 00-459; BLM Battle Mountain District	
NV04-HR-107	445.121	Butte Canyon (near Battle Mtn.)	Below historic mine site	Metals	USGS Open File Report 00-459; BLM Battle Mountain District	
NV04-HR-108	445.121	Galena Canyon (near Battle Mtn.)	Below historic mine site	Metals	USGS Open File Report 00-459; BLM Battle Mountain District	
NV04-HR-109	445.121	Rochester Canyon Creek (near Lovelock)	Below historic mine site	Metals	USGS Open File Report 00-459	
NV04-HR-110	445A.121	East Fork and West Fork Rock Creeks (near Battle Mtn.)	Below historic mine site	Metals	USGS Open File Report 00-459	
NV04-HR-111	Tributary to Pine Creek/Humboldt River - 445A.205	Trout Creek	Above Pine Creek	Total phosphorus	BLM - Elko District	
NV04-HR-112	445A.121	Little Cottonwood Creek (near Battle Mtn.)	Below historic mine site	Metals	BLM - Battle Mountain District	
NV04-HR-113	445A.121	Iron Canyon (near Battle Mtn.)	Below historic mine site	Metals	BLM - Battle Mountain District	
Truckee River Basin						
NV06-SC-40-C	445A.126	Little Washoe Lake	Little Washoe Lake	Iron (total) Mercury (total)	NDEP	
NV06-TR-100	445A.121	Perry Canyon/Mullen Creek	Below mine site	Metals pH	Nevada Bureau of Mines and Geology	

Table C-1. List of Waterbodies with Potential Problems (continued)

Carson River Basin						
NV08-CR-13-C	445A.126	Carson River	Lahontan Reservoir to Carson Sink	Iron (total)	NDEP	
NV08-CR-100	Tributary to Carson River - 445A.153	Brockliss Slough	Above Carson River	Fecal coliform	NDEP	7
NV08-CR-101	Tributary to Carson River - 445A.151	Indian Creek	At Stateline	Fecal coliform	South Tahoe Public Utilities District	
Walker River Basin						
NV09-WR-08	445A.166	East Walker River	East Walker River from Bridge B-1475 to the confluence with the W. Walker	Iron (total)	NDEP	
NV09-WR-12	445A.169	Desert Creek	Stateline to Confluence with West Walker River	Iron (total)	NDEP	
NV-09-WR-13-C	445A.126	Mason Valley Wildlife Management Area (North Pond only)	North Pond	Arsenic (total)	NDEP	
				Boron (total)		
				Dissolved oxygen		1
NV09-WR-18-A	445A.124	Corey Creek	Origin to point of diversion of the town of Hawthorne	Total dissolved solids	NDEP	
				Total phosphorus		3
Central Region						
NV10-CE-14-A	445A.124	Birch Creek	Origin to National Forest Boundary	Iron (total)	Meridian Gold	5
NV10-CE-25-B	445A.125	Illipah Reservoir	Entire Reservoir	pH	NDEP	2
NV10-CE-42-B	445A.125	Cave Lake	Entire Lake	pH	NDEP	4
NV10-CE-100	445A.121	Tybo Creek	Below mine sita	Arsenic	BLM, NDOW	
				Cadmium		
				Chromium		
				Copper		
				Iron		
				Lead		
				Manganese		
				Mercury		
				Nickel		
				Zinc		

Table C-1. List of Waterbodies with Potential Problems (continued)

Great Salt Lake Basin						
NV11-GS-05-A	445A.124	Silver Creek	Origin to National Forest Boundary	pH	NDEP	4
Colorado River Basin						
NV13-CL-05	445A.199	Las Vegas Wash	Wastewater treatment plants to Telephone Line Road	Fecal coliform	Wash Discharger Monitoring	6
NV13-CL-06	445A.201	Las Vegas Wash	Telephone Line Road to Lake Mead	Fecal coliform	Wash Discharger Monitoring	6
				Selenium (total)	NDEP	8
NV13-CL-07	445A.175	Virgin River	Stateline to Mesquite	Selenium (total)	NDEP	8
NV13-CL-09	445A.177	Virgin River	Mesquite to Lake Mead	Selenium (total)	NDEP	8
NV13-CL-16-B	445A.125	White River	National Forest boundary to confluence with Ellison Creek	Temperature	NDEP	
NV13-CL-25-C	445A.126	Echo Canyon Reservoir	Entire reservoir	Iron (total)	NDEP	
NV13-CL-100	445A.121	Caselton Wash	Below Caselton Tailings	Acid mine drainage	Interagency AML Environmental Task Force	

Footnotes

1. Sampling point may not be representative of conditions for this parameter.
2. Current pH standard is outdated and needs to be revised to 6.5 to 9.0 based upon current EPA recommendations. However, the available data show that the new pH criteria have not be met.
3. The phosphorus standard may not be appropriata for eutrophication control.
4. Current pH standard is outdated and needs to be revised to 6.5 to 9.0 based upon current EPA recommendations. The available data show that the new pH criteria will be met.
5. Data indicates that the iron originates in the watershed upstream of the Austin Gold Venture Mine and not from the mine site.
6. Based upon criteria guidelines in 445A.119 for noncontact recreation and propagation of wildlife
7. The fecal coliform criteria reads as follows: " Based on a minimum of not less than 5 samples taken over a 30-day period, the fecal coliform bacterial level may not exceed a geometric mean of 200 per 100 ml nor may more than 10 percent of the total samples taken during any 30-day period exceed 400 per 100 ml." NDEP collects 6 samples a year on the Brockliss Slough which is not frequent enough to evaluate the fecal coliform standard as written. For the Potential Problems list, NDEP dropped the 30-day time period solely for identifying possible problems needing further investigation.
8. The 96-hour criteria was exceeded, but the 1-hour criteria was not exceeded.

Appendix D

List of Delisted Waterbodies

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Table D-1. Delisted Waterbodies

Waterbody ID	NAC Reference	Waterbody Name	Reach Description	Size	Units	Pollutant or Stressor of Concern	Data Sources	Notes
Snake River Basin								
NV03-OW-20	445A.224	East Fork Owyhee River	Within Duck Valley Indian Reservation	6.31	miles	Iron	not applicable	1
						Total phosphorus		
						Total suspended solids		
						Turbidity		
Humbolt River Basin								
NV04-HR-04	445A.206	Humboldt River	Battle Mtn to Comus	81.36	miles	Lead	NDEP	2
Truckee River Basin								
NV06-TR-04	445A.187	Truckee River	East McCarran to Lockwood	5.85	miles	Total nitrogen	DRI/TMWRF	2
NV06-TR-05	445A.188	Truckee River	Lockwood to Derby Dam	15.15	miles	Total nitrogen	DRI/TMWRF	2
NV06-TR-06	445A.189	Truckee River	Derby Dam to Wadsworth	11.22	miles	Total nitrogen	DRI/TMWRF	2
NV06-TR-07	445A.190	Truckee River	Wadsworth to Pyramid Lake	28.07	miles	Total nitrogen	not applicable	1
						Total phosphorus		
						Turbidity		
Carson River Basin								
NV08-CR-04	445A.150	EF Carson River	Stateline to Highway 395	10.48	miles	Total suspended solids	NDEP	2
NV08-CR-05-01	445A.151	EF Carson River	Highway 395 to Highway 88	8.53	miles	Total suspended solids	NDEP	2
NV08-CR-05-02	445A.151	EF Carson River	Highway 88 to Muller Lane	2	miles	Total suspended solids	NDEP	2
Walker River Basin								
NV09-WR-02	445A.161	Topaz Lake	Topaz Lake (Nevada portion)	988	acres	Total phosphorus	NDEP	2
						Total suspended solids		2
NV09-WR-04	445A.163	West Walker River	Wellington to Confluence with East Walker River	25.69	miles	pH	NDEP	2
NV09-WR-07	445A.166	East Walker River	Stateline to Bridge B-1475	22.7	miles	Iron (total)	NDEP	2
NV09-WR-10	445A.168	Walker River	Within Walker River Indian Reservation	11	miles	pH	not applicable	1
Colorado River Basin								
NV13-CL-12	445A.211	Muddy River	Glendale to Lake Mead	25.07	miles	Arsenic	NDEP	3

Footnotes:

1. State water quality standards not applicable within tribal lands
2. Standard exceeded less in less than 10% of the samples
3. This reach was listed in error. Waterbody reach does not have drinking water supply identified as a beneficial use, therefore there is no arsenic standard applicable for this reach

Appendix E

Summary of NDEP Monitoring Program

Summary of NDEP Monitoring Program

Introduction

State Requirements:

The State must conduct a water quality monitoring program in order to evaluate the quality of the waters of the State. This evaluation is necessary in order to determine if the quality of the waters of the State are suitable for the beneficial uses associated with them. This monitoring strategy has been developed in order to describe the manner in which the State intends to comply with EPA's monitoring requirements.

Federal Requirements:

A monitoring program is needed so the EPA can assess the State's progress towards the goals of P.L. 92-500.

State Authority:

The State authority for conducting a monitoring program is contained in Nevada Revised Statute (NRS) 445.214 and 445.216.

Federal Authority:

In order for the State to receive a Federal Grant for a water pollution control program, it must operate an appropriate monitoring program on the quality of the navigable bodies of water in the State (PL 92-500; Section 106(e)).

Monitoring Program

The Nevada Division of Environmental Protection (NDEP) surface water monitoring network is described in Tables E-1 and E-2. Table E-1 lists the parameters analyzed in the monitoring program. The monitoring network started with the one contained in the State's plan of implementation which was adopted in 1967. Modifications were made and are continuing to be made to reflect review of the data base, recognize resource constraints and to coordinate and utilize other government agencies monitoring activities. The selection of the stations in the monitoring network are based on land use, water quality, hydro modifications and topography. The monitoring network is used to assess compliance with water quality standards, conduct trend analysis, validate water quality models and set total maximum daily loads (TMDL's). The data are also used to conduct nonpoint source assessments, compile the 303(d) List, 208 Plan Amendments, and compile the 305(b) report.

Table E-2 lists the sampling sites, frequency and STORET number of the routine monitoring network. The Bureau of Water Quality Planning samples other waters as needed for evaluating standards, developing nonpoint source assessment, and other special projects.

Table E-1

List of parameters analyzed in NDEP's routine monitoring network

Conventional Pollutants
Total Dissolved Solids
Total Suspended Solids
Electrical Conductivity
Turbidity
Color
pH - field
pH - lab
Temperature
Alkalinity ($CaCO_3$)
Bicarbonate ($CaCO_3$)
Bicarbonate ($CaCO_3$)
Carbonate (Co_3)
Carbonate ($CaCO_3$)
Kjeldahl-N

Metals (total and filtered)
Cadmium
Zinc
Chromium
Arsenic
Copper
Boron
Iron
Selenium
Mercury
Lead

Conventional Pollutants
Nitrate-NO_3
Nitrate-N
Nitrite-N
Ammonia-N
Total Nitrogen
Ortho - Phosphorus-P
Total Phosphorus-P
Chloride
COD
BOD
Sulfate
Calcium
Magnesium
Sodium
Hardness ($CaCo_3$)
Sodium Absorption Ratio

Bacteriology
Fecal Coliform
Fecal Streptococcus
E. Coliform

Table E-2
List of NDEP's Routine Monitoring Network

RIVER SYSTEM	Frequency Time/Year Agency	NDEP Station Number	STORET Number
WALKER RIVER SYSTEM			
Walker River at Wabuska	6 NDEP	W4	310030
Walker River at Schurz Bridge	6 NDEP	WSB	310127
Walker River at Mason Gage	6 NDEP	W9	310117
E.Walker River at Nordyke Road	6 NDEP	W3	310029
W.Walker River at Nordyke Road	6 NDEP	W4	310026
E.Walker River at the Elbow	6 NDEP	EFE	310109
E.Walker River at Ivy Ranch	6 NDEP	EF5	310112
W.Walker River at Hudson Gage	6 NDEP	W7	310118
E.Walker River at Stateline	6 NDEP	EFS	310028
W.Walker River at Topaz Lane	6 NDEP	W5	310023
W.Walker at Wellington	6 NDEP	W10	310025
Topaz Lake	6 NDEP	TOP	310024
Desert Creek	6 NDEP	DC	310033
Sweetwater Creek	6 NDEP	SWC	310027
Walker Lake at Sportsmans Beach	6 NDEP	WL	310652
HUMBOLDT RIVER SYSTEM			
Mary's River	6 NDEP	HS1	310087
N.F. Humboldt River at I-80	6 NDEP	HS2B	310188
N.F. Humboldt River at N.F. Ranch	6 NDEP	HS15	310585
N.F. Humboldt River at Taco Tunnel	6 NDEP	HS16	310584
Humboldt River at Osino Cutoff	6 NDEP	HS4	310080
S.F. Humboldt River below Dixie Cr	6 NDEP	HS3A	310089
Humboldt River near Carlin Bridge	6 NDEP	HS5	310081
Humboldt River near Palisade	6 NDEP	HS6	310082
Humboldt River at Battle Mountain	6 NDEP	HS7	310083
Humboldt River at Comus	6 NDEP	HS8	310084
Humboldt River near Imlay	6 NDEP	HS9	310085
Toulon Drain	6 NDEP	HS10	310091
Humboldt River near Humboldt Sink	6 NDEP	HS12	310086
Pine Creek	6 NDEP	HS13	310582
Maggie Creek	6 NDEP	HS14	310583
South Fork Reservoir	6 NDEP	SFR	310587
Below Rye Patch Reservoir	6 NDEP	H6	310079

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Table E-2
List of NDEP's Routine Monitoring Network

RIVER SYSTEM	Frequency Time/Year Agency	NDEP Station Number	STORET Number
COLORADO RIVER SYSTEM			
Colorado River at Willow Beach	4 NDEP	CL2	310054
Colorado River at Laughlin	4 NDEP	CL1	310055
Las Vegas Wash above Lake Las Vegas	4 NDEP	CL3	310070
Virgin River at Riverside Bridge	4 NDEP	CL6A	310032
Virgin River at Mesquite	4 NDEP	CL6	310037
Muddy River at Glendale	4 NDEP	CL4	310071
Muddy River near Overton	4 NDEP	CL11	310095
Muddy River above Reid Gardner	4 NDEP	MARG	
LAKE TAHOE TRIBUTARIES			
First Creek at Dale & Knotty Pine	6 NDEP	1A	310056
First Creek at Lakeshore Drive	6 NDEP	1B	310057
Second Creek at Second Creek Dr.	6 NDEP	2A	310058
Second Creek at Lakeshore Drive	6 NDEP	2B	310059
Wood Creek at Lakeshore Drive	6 NDEP	WO	310061
E.F. Third Creek at Hwy 27	6 NDEP	EF3A	310063
Third Creek at Lakeshore Drive	6 NDEP	3B	310064
W.F. Incline Creek at Hwy 27	6 NDEP	WFINCA	310065
Incline Creek at Lakeshore Drive	6 NDEP	INCL	310067
Lake Tahoe at Sand Harbor	6 NDEP	SH	310128
E.F. Incline Creek below Diamond Peak	6 NDEP	EFINCA	310066
Lake Tahoe at Cave Rock	6 NDEP	CR	310588
SNAKE RIVER SYSTEM			
E.F. Owyhee River below Slaughterhouse Creek	4 NDEP	E16	
E.F. Owyhee River below Mill Creek	4 NDEP	E15	
Mill Creek near Patsville	4 NDEP	E14	310591
E.F. Owyhee River above Mill Creek	4 NDEP	E4	310047
W.F. Bruneau River at Mind Ranch	4 NDEP	E5	310046
W.F. Jarbidge River below Jarbidge	4 NDEP	E6	310045
W.F. Jarbidge River above Jarbidge	4 NDEP	E7	310044
E.F. Jarbidge River above Murphys	4 NDEP	E11	310043
Salmon Falls Creek at Hwy 93	4 NDEP	E8	310041
Shoshone Creek	4 NDEP	E9	310042
Wildhorse Reservoir at Pier	4 NDEP	E13	310589
Below Wildhorse Reservoir	4 NDEP	E12	310586

Table E-2 (Continued) List of NDEP's Routine Monitoring Network			
RIVER SYSTEM	**Frequency Time/Year Agency**	**NDEP Station Number**	**STORET Number**
TRUCKEE RIVER SYSTEM			
Truckee River at Farad	12 DRI	T1	310000
Truckee River at Circle C Ranch	12 DRI	T7	310092
Truckee River at Idlewild	12 DRI	T2	310001
Truckee River at McCarran Bridge	12 DRI	T3	310002
Truckee River at Vista Gage	12 DRI	T4A	310006
Truckee River at Tracy	12 DRI	T5	310004
Truckee River at Wadsworth	12 DRI	T6	310005
Truckee River at Nixon	12 DRI	T10	310514
North Truckee Drain	12 DRI	T9	310513
Steamboat Creek above WWTP	12 DRI	T8	310502
(above are sampled by DRI and Truckee MeadowsWastewater Reclamation Facility)			
CARSON RIVER SYSTEM			
W.F. Carson near Paynesville	6 NDEP	C8	310008
E.F. Carson at Riverview	6 NDEP	C9	310011
E.F. Carson at Hwy 88	6 NDEP	C16	310152
E.F. Carson at Muller	6 NDEP	C15	310093
Brockliss Slough at Muller Lane	6 NDEP	C5	310060
W.F. Carson at Muller Lane	6 NDEP	C14	310165
Carson at Genoa Lane	6 NDEP	C3	310013
Carson at Cradlebaugh Bridge	6 NDEP	C2	310014
Carson at Mexican Gage	6 NDEP	C13	310167
Carson at New Empire Bridge	6 NDEP	C1	310015
Carson at Dayton Bridge	6 NDEP	C11	310022
Carson at Weeks Bridge	6 NDEP	C10	310016
Truckee Canal at Hwy 50	6 NDEP	C22	310510
Carson below Lahontan Dam	6 NDEP	C18	310106
Bryant Creek at Doud Springs	6 NDEP	BCU	310592
Daggett Creek at Foothill Roak	6 NDEP	C23	310007

11199

Table E-2 (Continued)
List of NDEP's Routine Monitoring Network

RIVER SYSTEM	Frequency Time/Year Agency	NDEP Station Number	STORET Number
STEAMBOAT CREEK SYSTEM			
Little Washoe Outfall	6 NDEP-WCCP*	SB1	310200
Steamboat Creek at Pleasant Valley	6 NDEP-WCCP	SB3	310201
Galena Creek	6 NDEP-WCCP	SB4	310202
Steamboat Creek at Rhodes Road	6 NDEP-WCCP	SB5	310203
Steamboat Ditch	6 NDEP-WCCP	SB6	310204
Steamboat Creek at Geiger Grade	6 NDEP-WCCP	SB7	310205
Whites Creek	6 NDEP-WCCP	SB8	310206
Thomas Creek	6 NDEP-WCCP	SB10	310207
Steamboat Creek at Short Lane	6 NDEP-WCCP	SB11	310208
Alexander Ditch	6 NDEP-WCCP	SB12	310209
Rio Poco Drain	6 NDEP-WCCP	SB14	310210
Boynton Slough	6 NDEP-WCCP	SB16	310211
Steamboat Creek near Pembroke Lane	6 NDEP-WCCP	SB17	310212
Yori Drain	6 NDEP-WCCP	SB18	310213
Steamboat Creek at Clean Water Way	6 NDEP-WCCP	SB19	310214
*Washoe County Comprehensive Planning			

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Ground-Water Quality Assessment of the Carson River Basin, Nevada and California—Results of Investigations, 1987–91

United States Geological Survey Water-Supply Paper 2356–A

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Ground-Water Quality Assessment of the Carson River Basin, Nevada and California— Results of Investigations, 1987-91

By ALAN H. WELCH, STEPHEN J. LAWRENCE,
MICHAEL S. LICO, JAMES M. THOMAS, and
DONALD H. SCHAEFER

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FOREWORD

The mission of the U S Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions Assessment of water-quality conditions and trends is an important part of this overall mission

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions These organizations are collecting water-quality data for a host of purposes that include compliance with permits and water-supply standards, development of remediation plans for specific contamination problems, operational decisions on industrial, wastewater, or water-supply facilities, and research on factors that affect water quality An additional need for water-quality information is to provide a basis on which regional- and national-level policy decisions can be based Wise decisions must be based on sound information As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies

To address these needs, the U S Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program In 1991, the USGS began full implementation of the program The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies The objectives of the NAWQA Program are to:

- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers
- Describe how water quality is changing over time
- Improve understanding of the primary natural and human factors that affect water-quality conditions

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 60 of the Nation's most important river basins and aquifer systems, which are referred to as study units These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings More than two-thirds of the Nation's freshwater use occurs within the 60 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program This effort focuses on selected water-quality topics using nationally consistent information Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available

This report is an element of the comprehensive body of information developed as part of the NAWQA Program The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public The assistance and suggestions of all are greatly appreciated

Robert M. Hirsch

Robert M Hirsch
Chief Hydrologist

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[Plate is in pocket]

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
acre	0.4047	square hectometer
acre-foot (acre-ft)	0.001233	cubic hectometer
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
gallon (gal)	0.003785	cubic meter
inch (in.)	25.4	millimeter
inch per year (in/yr)	25.4	millimeter per year
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Temperature: Degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by using the formula °F = [1.8(°C)]+32. Degrees Fahrenheit can be converted to degrees Celsius by using the formula °C = (°F - 32)/1.8.

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929, formerly called "Sea-Level Datum of 1929"), which is derived from a general adjustment of the first-order leveling networks of the United States and Canada.

Abbreviated Water-Quality Units Used in this Report

mg/kg (milligram per kilogram)
mg/L (milligram per liter)
µg/L (microgram per liter)
pCi/L (picocurie per liter)

Ground-Water Quality Assessment of the Carson River Basin, Nevada and California—Results of Investigations, 1987-91

By Alan H Welch, Stephen J. Lawrence, Michael S Lico, James M Thomas, *and* Donald H Schaefer

Abstract

The Carson River Basin is an area of dramatic contrasts The Carson River drains pristine wilderness of the forested Sierra Nevada, which provides much of the basin's water The chemical composition of the Carson River changes from that of a fresh, untamed white-water river in the Headwaters Area to that of stagnant saline sloughs and alkali lakes in the Carson Desert The ground-water quality, particularly in shallow aquifers, broadly mirrors the chemical changes in the river—a major source of recharge to basin-fill aquifers Contrasts in ground-water quality within the Carson River Basin are evident across the basin, among the different aquifers, and, to a lesser extent, between shallow ground water beneath urban and agricultural land.

Using current drinking-water standards as a measure of overall water quality, ground-water quality in principal aquifers in the upper basin generally is good Principal aquifers in the upper basin are a major source of supply for municipal systems that provide water to the communities of Minden, Gardnerville, and Carson City Precipitation falling on the Sierra Nevada, along with recharge from the Carson River in areas of heavy ground-water pumping, is the major source of recharge to principal aquifers Except for locally high concentrations of nitrate and presence of synthetic organic compounds, water quality in principal aquifers generally results from chemical reactions with aquifer materials Some ground water in and adjacent to the Sierra Nevada contains uranium concentrations greater than the proposed drinking-water standard Radon activities in the Sierra Nevada locally exceed 10,000 pCi/L and are highest in the Carson River Basin

Shallow aquifers in Carson Valley contain higher concentrations of most major constituents and, compared to water in principal aquifers, more commonly contain concentrations of some minor constituents that exceed drinking-water standards Manganese exceeds the secondary maximum contaminant level at more than 25 percent of the sampled sites Minor constituents that exceed drinking-water standards at less than 10 percent of sampled sites are arsenic, fluoride, nitrate, and iron Water from shallow aquifers more commonly contains concentrations of arsenic, fluoride, iron, and manganese in excess of the drinking-water standards than does water from the principal aquifers.

Shallow aquifers beneath the upper basin locally contain herbicides, pesticides, and volatile organic compounds Beneath the urban part of Carson City, prometone, trichloroethylene, and tetrachloroethylene were found at concentrations well above the laboratory minimum reporting level Trichloroethylene was found at concentrations above the drinking-water standard With a few exceptions, ground water beneath agricultural land in Carson Valley contained, at most, low concentrations of synthetic organic compounds

Principal aquifers beneath the sparsely populated middle Carson River Basin are recharged by precipitation falling on the uplands and, locally, by

the Carson River Concentrations of major constituents in water from principal aquifers in the lower basin generally are higher than in water from the principal aquifers of the upper basin Concentrations of dissolved solids, iron, manganese, and sulfate more commonly exceed drinking-water standards in principal aquifers of the middle than the upper basin

Carson Desert, at the distal end of the Carson River Basin, is a closed basin that loses water only by evapotranspiration Analyses of ground water indicate a wide range in concentrations of major and minor inorganic constituents, with dissolved solids reaching maximum concentrations greater than seawater Concentrations of sodium, chloride, bicarbonate, and dissolved solids generally are higher in shallow and principal aquifers of Carson Desert than in the upper and middle parts of the basin More than 10 percent of sampled ground water from shallow and principal aquifers contains concentrations of arsenic, dissolved solids, and manganese greater than the drinking-water standards

Several minor constituents reach unusually high concentrations in shallow aquifers of Carson Desert Notable are arsenic, iron, manganese, and uranium Among these four elements, all except uranium reach concentrations greater than 1 milligram per liter Processes leading to the high concentrations include evapotranspiration and reactions of sedimentary organic matter with metal oxides Locally, these reactions appear to be an indirect result of a rise in the water table in response to application of irrigation water for agricultural activities

INTRODUCTION

Background

This report summarizes results of one of seven pilot NAWQA projects selected to represent diverse hydrologic environments and water-quality conditions The seven pilot projects include three concerned with ground water and four concerned with surface water Ground-water project areas are the Carson River Basin in Nevada and California, the Central Oklahoma aquifer in Oklahoma, and the Delmarva Peninsula in Delaware, Maryland, and Virginia Surface-water project areas are the Yakima River Basin in Washington, the lower Kansas River Basin in Kansas and Nebraska, the upper Illinois River Basin in Illinois, Indiana, and Wisconsin, and the Kentucky River Basin in Kentucky

The Carson River Basin pilot project included several studies, some of which were discussed in reports on three subareas of the basin, and topics of special interest Reports describing the geochemistry and water-quality characteristics of ground water are available for Carson and Eagle Valleys (Welch, 1994, Thodal, 1989), Dayton and Churchill Valleys (Thomas and Lawrence, 1994), and Carson Desert (Lico and Seiler, 1994) Data assembled during the project are reported by Whitney (1994) Topics of special interest include the effects of urbanization on water quality (Lawrence, 1996), radionuclides in ground water (Thomas and others, 1990, 1993, Welch and others, 1990), minor inorganic constituents (A H Welch and M S Lico, U S Geological Survey, written commun , 1995), the chemistry of shallow sediments (Tidball and others, 1991), and fluorocarbon compounds as indicators of ground-water age (Sertic, 1992) These reports complement and update geochemical and hydrologic data available through 1987, as summarized by Welch and others (1989) This report summarizes the interpretations given in the reports cited above

Purpose and Scope

The primary purpose of this report is to describe the chemical quality of ground water in the Carson River Basin, with an emphasis on ground water in aquifers used for municipal and domestic water supply Included are discussions of the general water-quality characteristics and the physical and chemical processes producing the observed quality The hydrology of the area is discussed because water quality is affected by processes occurring as water flows through the basin

Unlike most of the earlier reports listed above, this report includes comparisons of water-quality characteristics throughout the basin Evaluation of isotope data complements hydrologic analyses based on geologic, hydrologic, and geophysical information Data collected during 1987-90 (Whitney, 1994) as part of the Carson River Basin NAWQA project are the principal basis for this report The discussion of ground-water quality includes statistical descriptions of the concentrations of major and minor inorganic constituents, radionuclides, and synthetic organic compounds For more in-depth explanations of the processes responsible for the observed water quality, sections describing processes that affect constituent concentrations, a description of the mineralogic composition of the sediments, and a discussion of the principles of isotope hydrology are included

Location System for Wells

Locations of ground-water sampling sites are identified using a "site identification" expressed in terms of local well numbers Local well numbers are based on the rectangular subdivision of public lands relative to the Mount Diablo base line and meridian A complete designation of a site consists of (1) the township number north of the base line, (2) the range east of the meridian, (3) the section number, (4) letters designating the quarter section, quarter-quarter section, and so-on (the letters "A," "B," "C," and "D" indicate northeast, northwest, southwest, and southeast quarters, respectively), and (5) a number distinguishing wells in the same tract within the section For example, well N17 E28 30 DBA 1 is the first recorded in the NE 1/4 NW 1/4 SE 1/4 of section 30, township 17 north, range 28 east Township and range numbers are shown along the margins of well-location maps

Acknowledgment

Appreciation is extended to residents and water purveyors in the Carson River Basin for permitting access to wells

DESCRIPTION OF THE STUDY AREA

***By* Donald H Schaefer**

Location and Physiography

Located within the western Great Basin and eastern Sierra Nevada, the Carson River Basin encompasses an area of about 3,980 mi^2 The area is mostly in western Nevada, but includes a small part in eastern California (fig 1) The basin is divided into six areas generally corresponding to hydrographic areas delineated by the Nevada Division of Water Resources (Rush, 1968) and California Department of Water Resources for management and allocation of water resources In downstream order through the basin, the areas consist of the mountainous Headwaters Area, Carson Valley, Eagle Valley, Dayton Valley, Churchill Valley, and Carson Desert Dayton Valley includes two subbasins known as Carson Plains and Stagecoach Valley Water quality is discussed for upper, middle, and lower Carson River Basin, corresponding to the Headwaters, Carson Valley and Eagle Valley areas (upper basin), the Dayton Valley and Churchill Valley areas (middle basin), and the Carson Desert area (lower basin) The boundary between the Headwaters and the Carson Valley areas is defined on the basis of surface-water drainage rather than the Nevada-California boundary used by Rush (1968) for Carson Valley An area to the west of the Carson River and east of Eagle Valley is included in the discussion of the upper Carson River Basin This area, which is formally part of the Dayton Valley hydrographic area, receives flow from Eagle Valley and probably contributes little ground-water flow to Dayton Valley

The Headwaters Area is composed of drainage basins of the East and West Forks of the Carson River and contains no areally extensive alluvial aquifers Steep local topography with mountain peaks reaching altitudes greater than 10,000 ft above sea level form this scenically spectacular area

Valley floors of the Carson River Basin generally are level and surrounded by high mountains Altitudes of valley floors range from nearly 5,000 ft in Carson Valley to about 3,800 ft in Carson Desert Altitudes of adjacent mountains range from 6,000 to 8,700 ft along divides in the middle and lower basin and from 9,000 to 11,000 ft in the upper basin

Major hydrographic features of the Carson River Basin (fig 1) include the East and West Forks of the Carson River in the Headwaters Area and southwestern Carson Valley, the main stem of the Carson River, Lahontan Reservoir on the lower Carson River, and the Truckee Canal, which transports water from the Truckee River to Lahontan Reservoir Other features include distributary channels, marshes, shallow intermittent lakes, and salt flats in Carson Desert, as well as the Carson Sink and Carson Lake, the terminal sinks of the Carson River Many small tributary streams enter the Carson River from adjacent mountains Some of these streams are perennial in valleys as far downstream as Eagle Valley, but with few exceptions are ephemeral to the east Most of the flow in the Carson River and its perennial tributaries comes from springtime melting of snow Some reaches of the river are dry

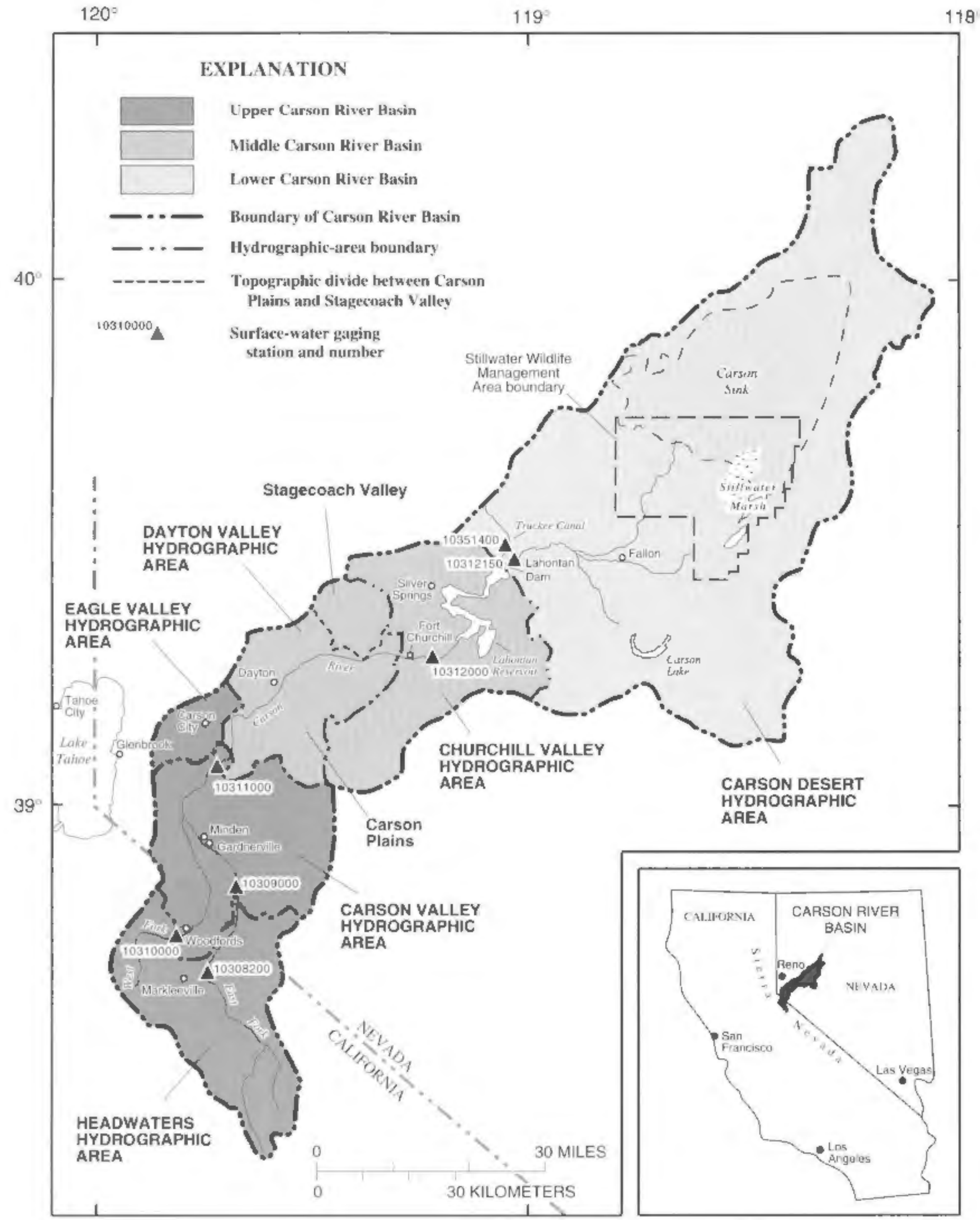


Figure 1. Location and hydrographic features of Carson River Basin.

during extended periods of drought Carson Valley and Carson Desert have extensive networks of ditches, drains, and sloughs

Climate

Climate of the Carson River Basin is dominated by the Sierra Nevada, which receives as much as 25-50 in/yr of precipitation at higher altitudes (Twiss and others, 1971, p 3) The region to the east, however, is distinctly drier because much of the moisture carried by winter storms from the Pacific Ocean falls as snow or rain in the Sierra Nevada This eastern region, including most of the Carson River Basin, lies in the rain shadow of the Sierra Nevada (Houghton and others, 1975, p 6) Climatic zones in the Carson River Basin vary from alpine in the Headwaters Area and the Carson Range of the Sierra Nevada in Carson Valley to arid in Carson Desert

Precipitation in the Carson River Basin falls as winter snow at high altitudes, as winter snow and rain at lower altitudes, and as summer thundershowers throughout the area Uplands, including much of the Headwaters Area, can receive 25 in/yr or more in an average year Valley floors and other low areas receive 3 to 11 in/yr (National Climatic Center, 1986, p 3) The effect of the Sierra Nevada rain shadow is apparent when comparing long-term precipitation totals at Virginia City to those at Glenbrook (along the east shore of Lake Tahoe), Markleeville, and Woodfords (Glancy and Katzer, 1976, p 18) The altitude at the Virginia City station is nearly the same as at the Glenbrook station and is higher than the Markleeville and Woodfords stations In spite of this, the Virginia City station, about 30 mi east of the Sierra coast, receives from 11 to 13 in/yr less precipitation than any of the other three stations in the headwaters

Land and Water Use

Agriculture and mining are historically the major land uses in the Carson River Basin Decline of mining in the basin in the 1880's was followed by an increase in irrigated acreage in Carson Desert due to the Newlands Project

In the upstream part of the study area, barren land is primarily exposed bedrock, whereas in the downstream part of the basin, barren land is primarily dry salt flats and other sandy areas Nearly 10,000 acres of land along the crest of the Sierra Nevada in the Headwaters Area and Carson Valley are classified as tundra The Headwaters Area remains largely undeveloped and sparsely populated More than 70 percent of the area is forested land

Carson Valley has been a major agricultural area in Nevada since the 1850's and contained about 47,000 irrigated acres in 1985 (Douglas K Maurer, U S Geological Survey, oral commun , 1986) The urban area in Carson Valley, primarily in Minden and Gardnerville, has increased considerably since the 1973-80 inventory shown in table 1 Eagle Valley, which contains Carson City, is largely urban and has only a small amount of agricultural land (about 1,000 acres in 1973)

Dayton and Churchill Valleys, which have the smallest populations of the hydrographic areas in the Nevada part of the basin, are primarily rangeland The valleys include agricultural areas along the Carson River

Carson Desert has the largest percentage of barren land because it contains the Carson Sink and other alkali flats During 1980-87, the estimated irrigated acreage in Carson Desert ranged from 61,000 to 67,000 acres (Bureau of Reclamation, 1987a) Urban land in Carson Desert consists of the city of Fallon and the Fallon Naval Air Station Construction of a 31-mi-long canal to divert Truckee River water to the Carson River was completed in 1905 Construction of Lahontan Dam on the Carson River, to store the diverted water and water from the Carson River, was completed in 1915 (Katzer, 1971) Since 1914, irrigated acreage in the Newlands Project area, which includes land along the Truckee Canal, has ranged from as little as 39,449 acres in 1916 to as much as 67,294 acres in 1979 The Fallon National Wildlife Refuge was established in 1931 and the Stillwater Wildlife Management Area and Stillwater National Wildlife Refuge were established in 1948

Other than changes associated with the Newlands Project, land use and population in the Carson River Basin were relatively stable from the 1890's until about 1950 Urban and suburban development began to increase during the 1950's and has been increasing rapidly since the 1960's Minden, Gardnerville, Carson City, and Fallon have grown considerably, as have rural populations throughout much of the basin Most of the urban and suburban development has been on land previously used for agriculture (either irrigated cropland or rangeland)

Land uses in the basin, by acreage and as a percent of the total basin, are listed in table 1 Because of rapid urban and suburban growth since the compilation

Table 1 Land use and land cover in Carson River Basin, Nevada and California, by hydrographic area, 1973-80 [1]

[Upper number is area, in acres Number in parentheses is percentage of total acreage for each hydrographic area Land-use areas that constitute more than 25 percent of a hydrographic area are shown in **bold** type Due to rounding, sum of individual percentages may not be 100 percent Symbol <, less than]

Hydrographic area (years for which data apply)	Urban	Agricultural	Range	Forest	Water	Wetland	Barren	Tundra	Total (rounded)	
									Acres	Percent of Carson River Basin
Headwaters Area (1973-79)	49 (<0 1)	0 (0)	62,000 (23)	**190,000** **(72)**	410 (0 2)	300 (0 1)	2,500 (0 9)	8,800 (3 3)	270,000	11
Carson Valley (1973-79)	3,400 (1 2)	47,000 (16)	**98,000** **(34)**	**130,000** **(45)**	470 (2)	5,300 (1 9)	1,400 (5)	1,600 (6)	280,000	11
Eagle Valley (1973)	[2]4,800 (10)	1,100 (2 3)	**28,000** **(60)**	**12,000** **(26)**	0 (0)	0 (0)	450 (1 0)	0 (0)	47,000	2
Dayton Valley (1973)	950 (4)	4,800 (2 0)	**150,000** **(65)**	**70,000** **(30)**	9 (<0 1)	1,600 (7)	4,700 (2 0)	0 (0)	230,000	9
Churchill Valley (1973)	720 (2)	1,700 (5)	**250,000** **(79)**	21,000 (6 7)	7,500 (2 4)	7,000 (2 2)	28,000 (8 8)	0 (0)	320,000	12
Carson Desert (1973, 1980)	[2]5,600 (4)	79,000 (5 7)	**580,000** **(42)**	30,000 (2 1)	23,000 (1 6)	62,000 (4 4)	**600,000** **(44)**	0 (0)	1,400,000	55
Carson River Basin totals (rounded)	15,000 (6)	130,000 (5 2)	**1,200,000** **(46.1)**	450,000 (17 9)	31,000 (1 2)	76,000 (3 0)	**640,000** **(25.2)**	10,000 (4)	2,500,000	100

[1] Data sources U S Geological Survey, 1979, 1980, 1983 (maps interpreted from photographs taken during 1973-79 for areas south of 39 degrees latitude, in 1973 for areas between 39 and 40 degrees latitude, and in 1980 for areas north of 40 degrees latitude)

[2] Carson Desert has less than one-half the population of Eagle Valley, but it has more urban land because Fallon Naval Air Station is classified as urban land

period (1973-80), the distribution and percentage of urban land are now different, although the numbers in the table represent the most current information available for the basin as a whole Carson Valley and the Carson Desert contain more than 90 percent of the agricultural land in the basin Forest land predominates in the Headwaters Area and in Carson Valley, and decreases markedly toward the downstream part of the study area Rangeland increases eastward from Dayton Valley to Churchill Valley to Carson Desert

Areal extent of water bodies and wetlands is highly variable, both seasonally and from year to year This is especially true in Carson Desert For example, between July 1984 and February 1985, following three unusually wet years, the surface-water area of the Carson Sink was about 200,000 acres (Rowe and Hoffman, 1990) By April 1988 (during a second consecutive drought year), the sink was dry (Rowe and Hoffman, 1990) Major water bodies in the basin are the Lahontan Reservoir in Churchill Valley and ephemeral lakes, reservoirs, and alkali flats in Carson Desert

Demand for water in the Carson River Basin exceeded supply soon after the area was settled Historically, court suits regarding water rights in the basin follow drought years (Dangberg, 1975, p 134-135 and unnumbered plate) In the 1980's, major water-management issues in the Carson River Basin included distributing available water and finding new sources of water to support urban and suburban growth, farming interests, and wildlife management Many water-use and water-allocation disputes in the Carson River Basin and between the Truckee River and Carson River Basins await decision by the courts and negotiations as of 1990

Basinwide estimates of water use in 1969, 1975, and 1988 are listed in table 2 Trends (1969-88) in ground-water use are shown in figure 2 and include estimates for 1985 from Welch and others (1989, table 19) The significant decline in surface-water use between 1985 and 1988 is due to a combination of changes in operation of the large Newlands Irrigation Project in the lower Carson River Basin and effects of relative drought in 1987 and 1988 Withdrawals of ground water for public water supply (combined with self-supplied domestic use and labeled as domestic use in fig 2) increased from 3,900 acre-ft in 1969 to about 21,000 acre-ft in 1988 The estimated ground-water withdrawal for self-supplied domestic use has more than tripled

Table 2 Estimated basinwide water use in Carson River Basin, Nevada and California, 1969, 1975, and 1988

[Estimated withdrawals, in acre-feet, are significant to no more than two figures, columns may not cross-total because of independent rounding Abbreviations GW, ground water, RS, reclaimed sewage, SW, surface water, --, no data]

Type of water use	1969 [1]				1975 [2]				1988 [3]			
	GW	SW	RS	Total	GW	SW	RS	Total	GW	SW	RS	Total
Public supply	2,700	1,200	0	3,900	5,900	480	0	6,400	16,900	1,600	0	18,500
Self-supplied domestic	1,200	40	0	1,200	1,700	50	0	1,800	4,100	40	0	4,100
Livestock (non-irrigated agriculture)	120	440	0	560	[4]2,200	870	0	3,100	[5]2,600	1,800	0	4,400
Irrigation	6,000	[6]670,000	[7]--	680,000	8,800	650,000	[8]900	660,000	18,600	260,000	5,400	280,000
Thermoelectric power	0	0	0	0	0	0	0	0	0	0	0	0
Self-supplied commercial, industrial, and mining	1,200	430	0	1,600	[4]1,300	[9]300	[8]--	1,600	1,300	100	0	1,400
Total withdrawal (rounded)	11,000	670,000	[7]--	690,000	20,000	650,000	900	670,000	44,000	260,000	5,400	310,000

[1] Smales and Harrill (1971, p 17, 29, and 30)

[2] James R Harrill and Jon O Nowlin (U S Geological Survey written commun 1976)

[3] U S Geological Survey files, 1990

[4] For 1975, estimate of self-supplied industrial water use includes 2,200 acre-feet of ground water withdrawn by the Lahontan Fish Hatchery For consistency with 1988 categories of water use, those 2,200 acre-feet are included in nonirrigated agriculture A very small percentage of this water is lost from the system

[5] Includes 1,900 acre-feet of ground water withdrawn by the Lahontan Fish Hatchery A very small percentage of this water is lost from the system

[6] Includes 114,000 acre-feet diverted from Truckee River into Derby Canal

[7] In 1969, 2,900 acre-feet of treated sewage effluent from the Lake Tahoe Basin was imported to the Carson River Basin, but the amount used for irrigation was not recorded (Glancy and Katzer, 1976, p 53)

[8] In 1975, the estimate of self-supplied industrial water use included 500 acre-feet of reclaimed sewage applied to the Carson City Golf Course For consistency with 1988 categories of water use, that 500 acre-feet is included as irrigation

[9] In 1975, the estimate of self-supplied industrial water use included 2,000 acre-feet of surface water withdrawal by Huck Salt Company in Carson Desert Water on the salt flats flows naturally and is not diverted or withdrawn Salt-mining operations do not affect natural evaporation rates For consistency with 1988 estimates, the 2,000 acre-feet included in the original 1975 estimates is not included in above table

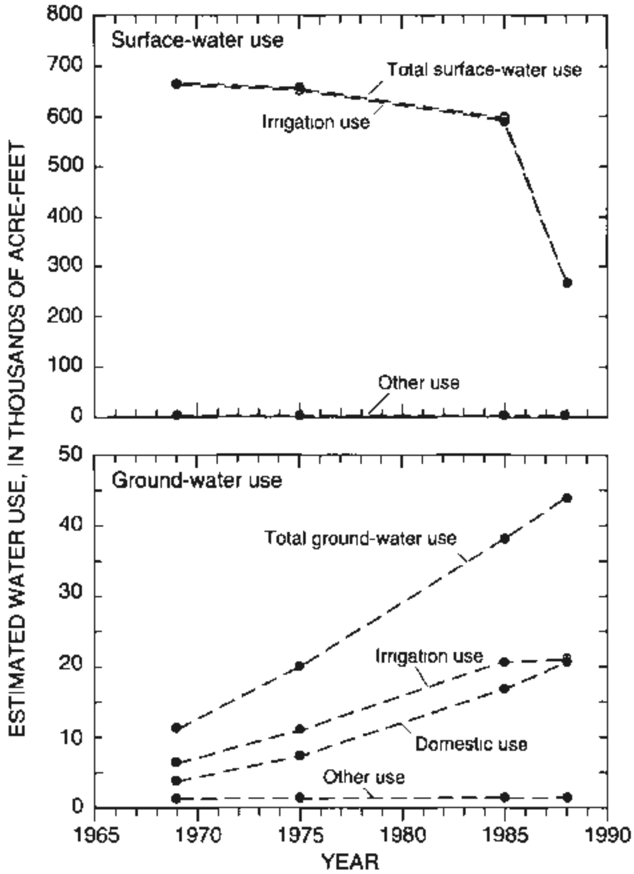


Figure 2 Estimated water use in Carson River Basin, Nevada and California, 1969-88

Total water use in the Carson River Basin for 1988 is estimated to be 310,000 acre-ft, more than 80 percent was surface water diverted for irrigation (table 2) Although ground water accounts for only 14 percent of the total water use, it supplies 93 percent of the amount withdrawn for domestic use

Sewage effluent returned to ground-water and surface-water systems of the study area has the potential to degrade regional ground-water quality Estimates of effluent discharged in each hydrographic area in 1985 are detailed by Welch and others (1989, table 6) Four sewage-treatment facilities within the Lake Tahoe Basin began exporting effluent to the Carson River Basin between 1968 and 1971 (Glancy and Katzer, 1976, p 50-53), for more than 10 years (as of 1988), all effluent from the Lake Tahoe Basin has been exported to the upper Carson River Basin Treated sewage effluent is used for irrigation in Carson Valley and Eagle Valley Similar applications are made on 20 acres in Carson Desert

HYDROGEOLOGIC SETTING

Geologic Framework

***By* Donald H Schaefer**

Alluvial valleys in the Carson River Basin are located in structural basins formed by extensional faulting during the Tertiary and Quaternary periods of geologic time These basins are bounded laterally by consolidated rocks of adjacent mountain ranges and at depth by consolidated rocks of the down-faulted valley blocks, and contain basin-fill deposits that range in thickness from 2,000 to 12,000 ft Aquifers in the Carson River Basin are mostly these basin-fill deposits

Differences in lithology and rock chemistry allow grouping of the consolidated rocks into five hydrogeologic units (pl 1, Welch and others, 1989) (1) Metasedimentary and metavolcanic rocks of Triassic and Jurassic age, (2) basic igneous rocks consisting of diorite, gabbro, and marine volcanic rock of Jurassic age, (3) granodiorite and quartz monzonite of Jurassic to Tertiary age, (4) silicic volcanic rocks consisting of rhyolite, latite, and dacite of Tertiary and Quaternary age, and (5) basic volcanic rocks consisting of basalt, andesite, and trachyte of Tertiary and Quaternary age Except for Jurassic basic igneous rocks, which are found only in the West Humboldt and Stillwater Ranges, each of these units is widespread in the basin

Basin-fill deposits include sediments of Tertiary and Quaternary age Tertiary sediments consist of clays, silts, sands, and gravels In former times, these deposits were more extensive than in the modern basins These older deposits are exposed in mountain blocks and along basin margins and presumably make up the deeper part of the basin-fill deposits in each basin For purposes of this report, Tertiary sediments are considered part of the basin-fill deposits

Younger deposits are at and near the land surface in each basin and include poorly sorted to unsorted clay, silt, sand, and gravel of alluvial fans, pediments, and basin lowlands Some of these deposits are associated with Pleistocene Lake Lahontan, ancient Carson River deltas, and past and present flood plains of the river Lake Lahontan was a Late Pleistocene pluvial lake that covered much of the eastern half of the basin during its highest stand (fig 3) Fine-grained deposits accumulated mostly as lacustrine and deltaic sediments of Lake Lahontan and, depending on the level of the lake, as fluvial sediments of the Carson River flood plain Locally, basin-fill deposits are interbedded with

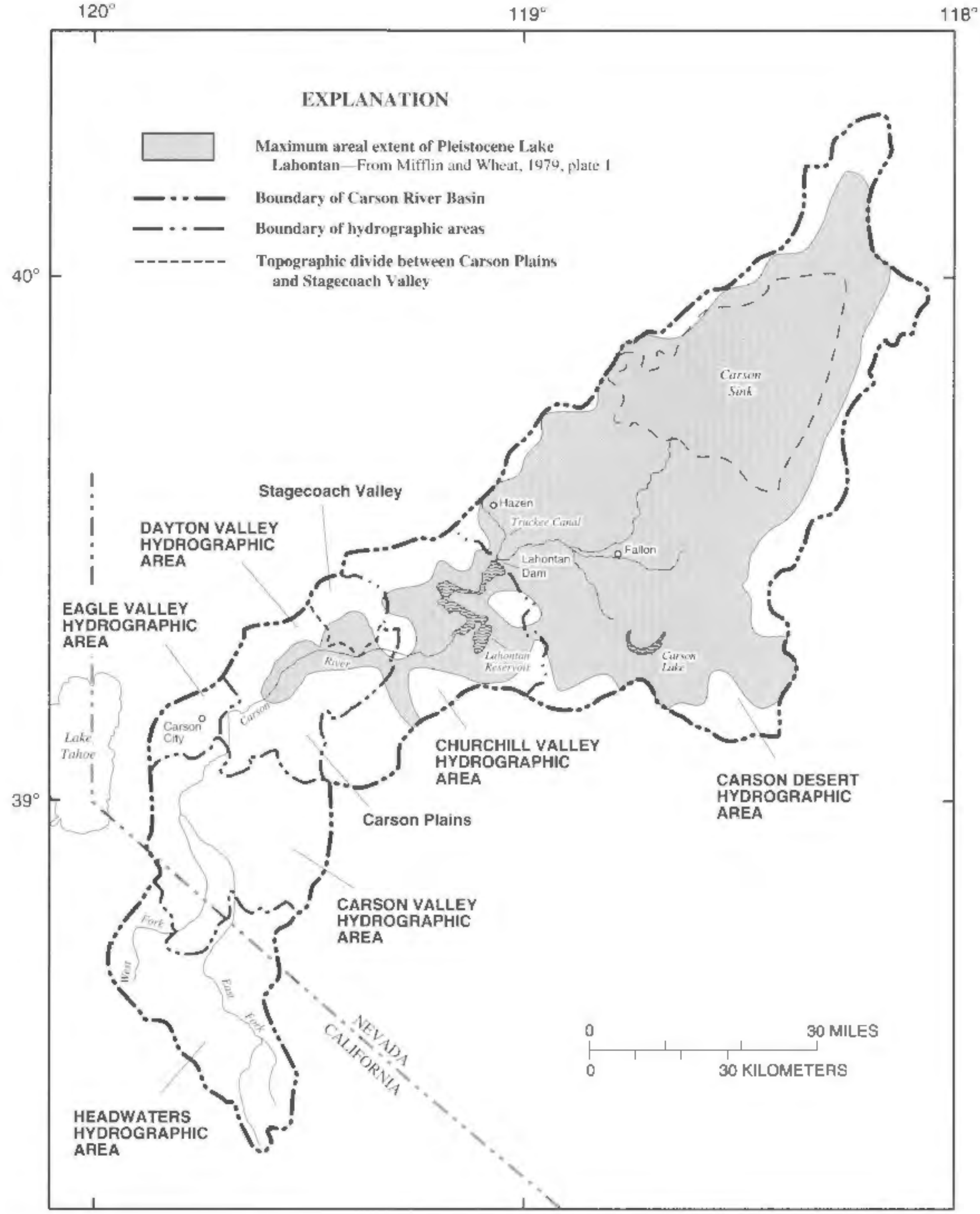


Figure 3. Maximum extent of Pleistocene Lake Lahontan in Carson River Basin.

volcanic rocks These volcanic rocks are considered part of the basin-fill deposits One important aquifer in southern Carson Desert is composed of basalt and is exposed at Rattlesnake Hill This basalt aquifer is the source of public supply for the city of Fallon and the Fallon Naval Air Station

A dominant hydrologic feature of the Carson River Basin is the Carson River, which provides a connection between the valleys of the basin The river flows through and physically connects the Headwaters Area, Carson Valley, Dayton Valley, Churchill Valley, and Carson Desert Shallow aquifers are hydraulically connected to the river in these valleys Depending on flow, reach of the river, and local irrigation practices, the river either can be a source of ground-water recharge or can receive discharge The Carson River does not enter Eagle Valley or Stagecoach Valley, although both are hydraulically connected to the river, either by tributary streams in Eagle Valley or by ground-water underflow in Stagecoach Valley

Mineralogic Composition of the Aquifers

By Michael S Lico

Knowledge of an aquifer's mineralogic composition can lead to an understanding of reactions affecting constituent concentrations in ground water of the Carson River Basin It is important to determine whether precipitation or dissolution of mineral phases has occurred In some mineral samples, distinguishing whether features were formed in place or at another location and transported to a present location is difficult The mineralogic composition of parts of Carson Desert is described by Lico and others (1986, 1987) and Lico (1992)

Igneous rocks form the bulk of the bedrock uplands (table 3) As a result, minerals forming the basin-fill sediment reflect the igneous origin of upland areas The Sierra Nevada batholith, which is composed mostly of silicic rocks including granodiorite and quartz monzonite, has been a major source of sediment transported by the Carson River since the Late Tertiary

Table 3 Area of shallow or exposed bedrock of Carson River Basin, Nevada and California, by hydrographic area

[Upper number is area, in square miles Number in parentheses is percentage of total bedrock outcrop area for each hydrographic area Bedrock areas that constitute more than 25 percent of a hydrographic area are in **bold** type Due to rounding, sum of individual percentages may not be 100 percent Silicic rocks are sum of QTsv and TJsi Abbreviations QTbv, basic volcanic rocks, QTsv, silicic volcanic rocks, TJsi, intrusive igneous rocks, Jm, Jurassic igneous rocks, JTRm, metasedimentary and metavolcanic rocks, mi^2, square miles]

Hydrographic area	Total area (mi^2)	QTbv	QTsv	TJsi	Jm	JTRm	QTsv+TJsi
			Upper Carson River Basin				
Headwaters area	365	**210** **(58)**	21 (6)	**123** **(34)**	0 (0)	11 (3)	144 (39)
Carson Valley	169	42 (25)	2 (1)	**75** **(44)**	1 (1)	**49** **(29)**	77 (46)
Eagle Valley	58	5 (8)	2 (3)	**31** **(53)**	0 (0)	**21** **(35)**	33 (57)
Subtotal	592	**257** **(43)**	25 (4)	**229** **(39)**	1 (0)	81 (14)	254 (43)
			Middle Carson River Basin				
Dayton Valley[1]	244	**176** **(72)**	5 (6)	24 (10)	0 (0)	30 (12)	38 (16)
Churchill Valley	268	**197** **(73)**	46 (17)	14 (5)	0 (0)	11 (4)	60 (22)
Subtotal	513	**373** **(73)**	61 (12)	38 (7)	0 (0)	41 (8)	99 (19)
			Lower Carson River Basin				
Carson Desert	463	**254** **(55)**	98 (21)	21 (5)	28 (6)	62 (13)	119 (26)
Carson River Basin total	1568	**883** **(56)**	184 (12)	288 (18)	29 (2)	184 (12)	472 (30)

[1] Dayton Valley includes Carson Plains and Stagecoach Valley

Table 4 Minerals and alteration products in shallow sediment of Carson River Basin, Nevada and California

[Due to rounding, sum of individual percentages may not be 100 percent Abbreviations C, chlorite, D, dissolution, H, hematite, I, illite, K, kaolinite, M, montmorillonite (beidellite), N, no alteration, S, sericite **Bold** letters indicate strong alteration Symbol --, mineral not detected]

Component	Percentage of total (alteration)		
	Carson Valley (27 samples)	Dayton and Churchill Valleys (5 samples)	Carson Desert (27 samples)
Quartz	20 (N)	18 (N)	22 (N)
Plagioclase feldspar	26 (C,I,K)	19 (C,S)	26 (C,S)
Potassium feldspar	9 (C,K)	4 (C,S)	6 (C,S)
Volcanic lithic fragments	34 (C,H,I,S)	29 (C,H,I,S)	23 (C,H,I,S)
Sedimentary lithic fragments	8 (**C**)	27 (C,H,I,K,M,S)	18 (C,H,I,M,S)
Biotite	1 (**C, D**)	1 (**C**)	2 (**C**)
Hornblende	trace (C)	--	trace (C,D)
Pyroxene (augite)	1 (C)	1 (C,D)	1 (C,D)
Opaque minerals	1 (H)	1 (H)	1 (H)
Total (all components)	100	100	99

Silicic rocks are most commonly found in the upper basin and constitute about 40 percent of the exposed bedrock

Volcanic rocks formed mountain ranges within the basin and also are major sources of sediment for the basin-fill deposits In the upper basin, basic volcanic rocks are exposed throughout much of the Headwaters Area (table 3) Volcanic rocks are more common in the middle and lower basin than in the uplands of Carson and Eagle Valleys Almost three-quarters of the bedrock in the middle basin is volcanic As a result, volcanic-rock fragments constitute a major part of the basin-fill sediment Coarse-grained granodiorite and quartz monzonite commonly break down to grains consisting of single minerals Consequently, few granodiorite or quartz monzonite rock fragments are found in the basin-fill sediment In contrast, volcanic rocks are typically fine grained and more commonly survive transport as rock fragments

Minerals from 59 sediment samples were identified by electron microscopy, X-ray diffraction, and visually from thin sections and hand specimens (table 4) The most commonly identified phases are those included in geochemical models discussed later in this report Plagioclase feldspar generally has a more calcium-rich composition with increasing distance from the Sierra Nevada (fig 4) Increasing dominance of basalt in the middle compared to the upper basin is a likely source for the more calcium-rich plagioclase An alternative explanation is preferential weathering of sodium relative to calcium in the feldspar

Calcite is a common secondary mineral in basin-fill deposits of dry climates Although calcite was not found in sediment samples from Carson or Eagle Valleys, its presence in these sediment deposits is likely Calcite constitutes a small amount of the basin-fill sediment in Churchill Valley and Carson Desert as shell fragments and tufa in the Pleistocene lacustrine deposits of Lake Lahontan Secondary calcite also is present as coatings on shell fragments and cavity-filling cement (Lico, 1992) in basin-fill deposits of Carson Desert (fig 5) Calcite also forms in the unsaturated zone of Carson Desert (Lico and others, 1987)

Gypsum is commonly found in desert soils Triassic to Jurassic evaporite deposits (mostly gypsum) are present in northwestern Dayton Valley and the West Humboldt Range of northern Carson Desert These deposits release gypsum into the basin-fill sediment However, no gypsum was seen in the five sediment samples from Dayton Valley Gypsum was found in shallow sediment near the Stillwater Wildlife Management area (Lico, 1992)

Most basin-fill sediment is altered (table 4) Typically, volcanic lithic fragments are highly altered Chlorite, the most abundant alteration product, probably formed before the sediment was transported to its current location rather than being a product of reactions in the aquifers Alteration of minerals to chlorite usually occurs in low-grade metamorphic or hydrothermal conditions These conditions are rare in the aquifers of the Carson River Basin except in active geothermal

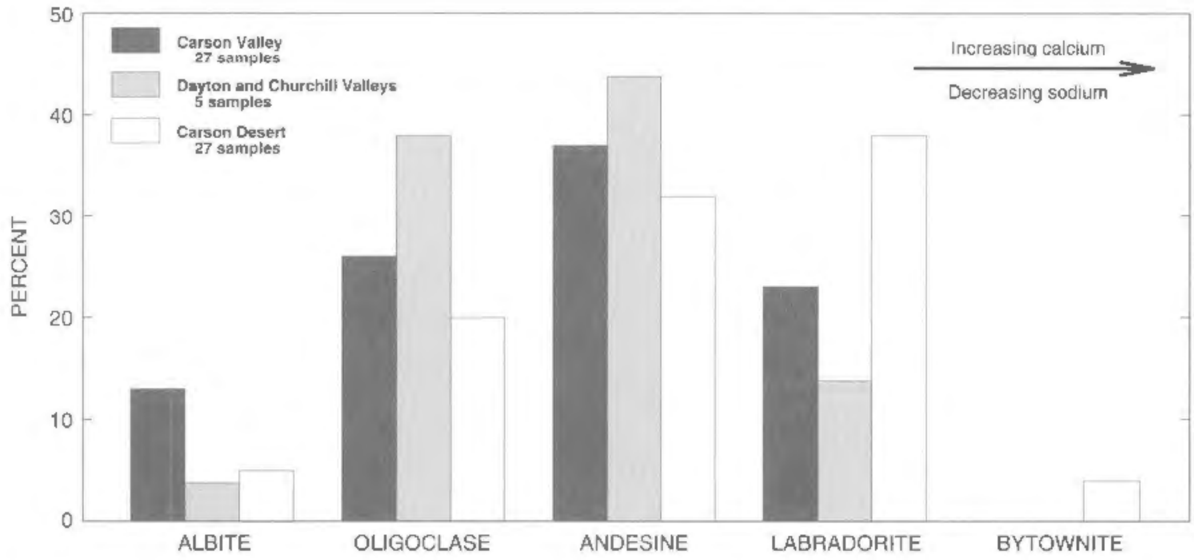


Figure 4. Composition of plagioclase feldspar in shallow sediments of Carson River Basin, Nevada and California, by hydrographic area.

areas. Plagioclase feldspar is altered to chlorite, sericite, illite, or kaolinite along cleavage planes and fracture surfaces. Sericite is increasingly abundant with distance from the Sierra Nevada. Kaolinite, an alteration product of plagioclase and potassium feldspars, was found mostly in samples collected near the Sierra Nevada. Hematite commonly forms on volcanic and sedimentary lithic fragments throughout the Carson River Basin (fig. 6). In a few samples throughout the basin, pyroxene (augite), biotite, and hornblende grains have dissolution features.

Plagioclase feldspar, potassium feldspar, and augite are the principal minerals that compose the basalt aquifer in Carson Desert. Minerals formed after initial cooling of basalt include calcite (with about 2.5 mole percent magnesium), phillipsite (a potassium-calcium zeolite), and an unidentified clay mineral. Pyroxene in the basalt aquifer has been slightly altered to chlorite. Plagioclase feldspar laths have minor illitic or sericitic alteration along cleavage planes. Edges of the iron-bearing minerals magnetite and ilmenite have been commonly altered to hematite.

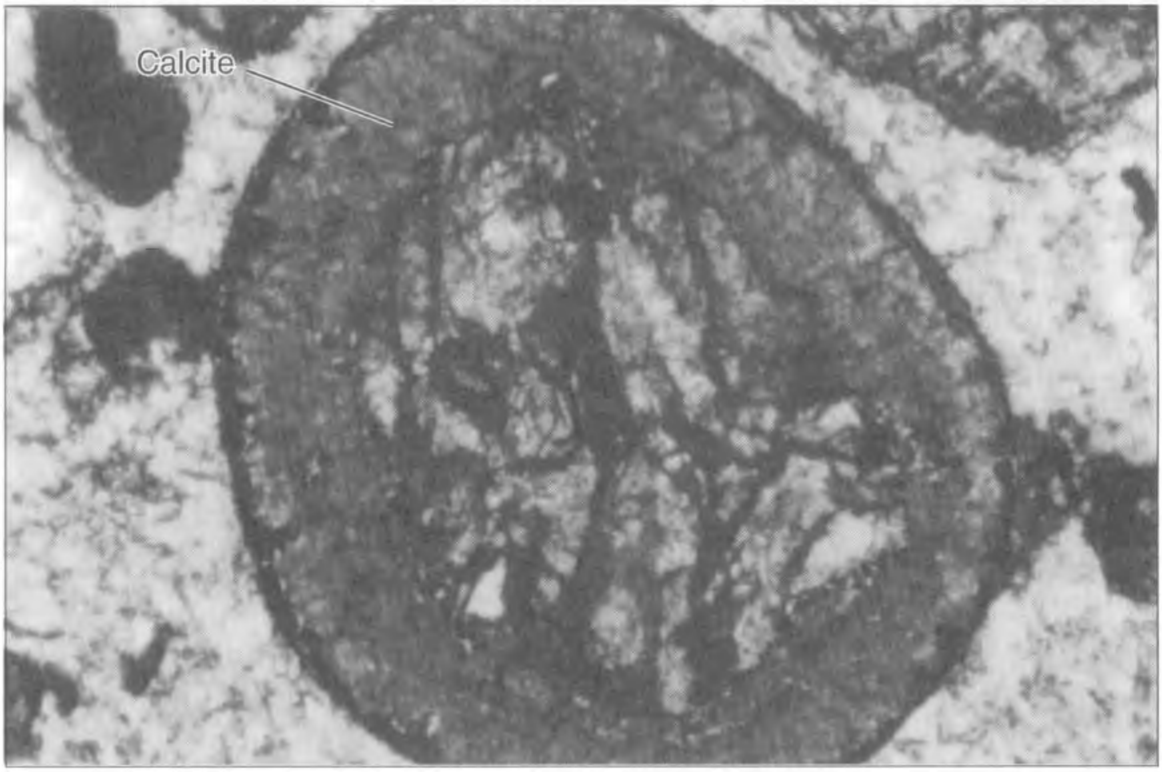
General Principles of Isotope Hydrology

By **Alan H. Welch**

Isotopes provide information on a variety of hydrologic processes, including sources of recharge and age of ground water. Information presented in this section provides the basis for interpretation of isotopic data in unraveling hydrologic processes in the Carson River Basin.

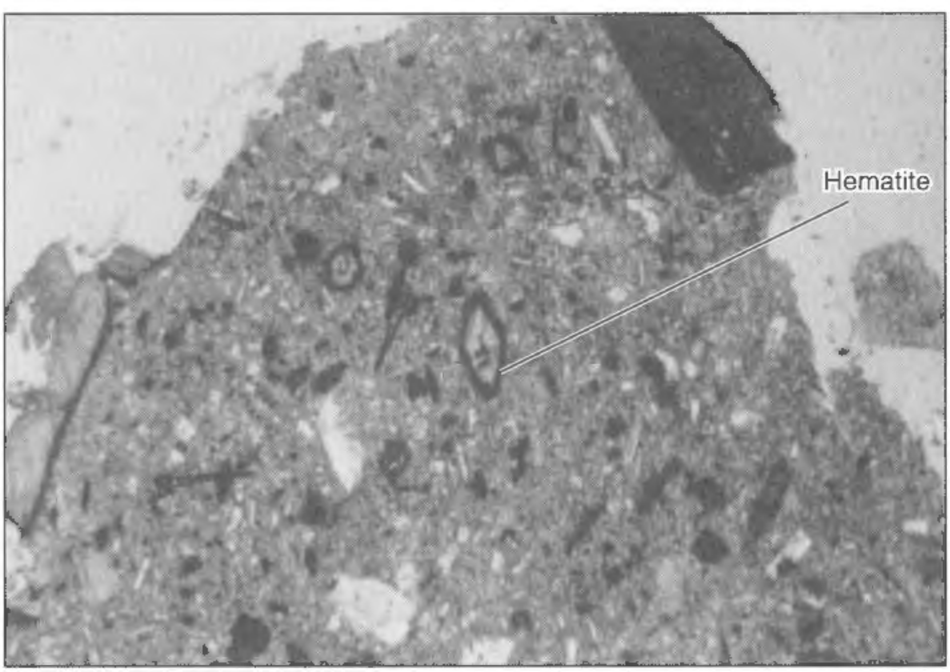
Commonly measured stable isotopes of water are the hydrogen isotopes with atomic masses of 1 and 2 (deuterium) and oxygen isotopes with atomic masses of 16 and 18. Isotopes of these two elements are expressed as ratios and related to comparable ratios for a standard called "Vienna Standard Mean Ocean Water" or V-SMOW (Fritz and Fontes, 1980, p. 11-14). Differences from the standard are expressed as delta deuterium (δD) and delta oxygen-18 ($\delta^{18}O$); the units are expressed as "permil" (o/oo). Because of the convention adopted for calculating delta values, more negative delta values are isotopically lighter than less negative values (Fritz and Fontes, 1980, p. 4-5).

Isotopic compositions of nonthermal ground water generally are different from those of local meteoric water because the compositions are affected by processes occurring during recharge and discharge. Evaporation in the near-surface environment during recharge and discharge is a major factor affecting the isotopic composition of ground water and surface water in the Carson River Basin. Rock-water interaction at temperatures greater than about 150°C also can affect the isotopic composition of oxygen. Important mechanisms affecting the stable-isotope composition of ground water in the Basin and Range Province are discussed below.



Approximately 0.4 millimeter

Figure 5. Calcite overgrowth in shallow sediment from southern Carson Desert, Nevada. Photomicrograph by William Carothers, U.S. Geological Survey, May 1986.



Approximately 1 millimeter

Figure 6. Hematite rims on pyroxene in shallow sediment from Carson Valley, Nevada. Photomicrograph by Patrick Goldstrand, U.S. Geological Survey, November 1990.

Although the isotopic composition of precipitation commonly varies widely from storm to storm (Gat, 1980, p 37-39), the average composition at a site commonly lies along a regression line called the "meteoric-water line " The slope of the regression is

$$\delta D = 8\delta^{18}O \qquad (2)$$

Precipitation in dry climates is heavier in deuterium (δD), compared with oxygen-18 (^{18}O), than suggested by the simple relation of equation 1 Thus, the meteoric-water line is displaced upward from the lower regression line, labeled "ground-water recharge," shown in figure 7 This displacement is commonly called the "deuterium excess parameter" (Dansgaard, 1964), or "deuterium excess" (*d*) The general equation of the meteoric-water line is

$$\delta D = 8\delta^{18}O + d \qquad (3)$$

A widely used "*d*-value" is 10 permil for atmospheric precipitation, on the basis of a study by Craig (1961) of many places in the world (see upper meteoric-water line in fig 7) The isotopic composition of ground-water recharge from precipitation in northern Nevada may be estimated from measurements of non-geothermal ground water with chloride concentrations less than 25 mg/L Low chloride concentrations indicate evaporation has not greatly affected the stable-isotope composition of the water The linear relation between the oxygen and hydrogen-isotope composition in ground water of northern Nevada with deuterium concentrations ranging from -130 to -100 is

$$\delta D = 6\ 94\delta^{18}O - 10\ 6 \qquad (4)$$

This equation compares favorably with a regression equation for rain in southeastern California that has a slope of 6 5 and a *d*-value equal to -9 7 (Friedman and others, 1992, fig 9) Data for 206 sites north of 38 degrees north latitude in Nevada were used for the regression A linear regression for ground water with chloride concentrations less than or equal to 10 mg/L yields a slope of 6 60, deuterium excess of -14 2, and a correlation coefficient of 0 84 for 127 analyses This line, although not shown in figure 7, would plot near the "ground-water recharge" line Similar regression equations suggest evaporation has not greatly affected the isotope composition because the chloride concentrations increased from 10 to 25 mg/L Within this range of chloride concentration, the increase may come from aquifer materials rather than evaporative concentration

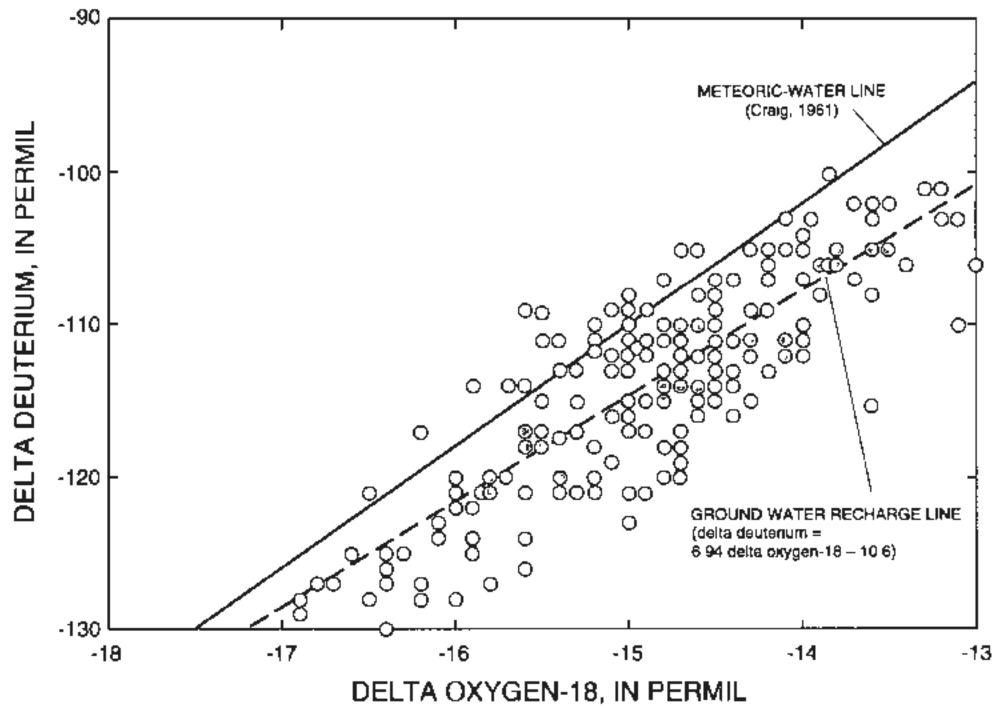


Figure 7 Relation between stable isotopes of hydrogen (delta deuterium) and oxygen in ground water of northern Nevada

In general, the stable-isotope composition of precipitation becomes progressively lighter with increasing distance east of the Sierra Nevada (Ingram and Taylor, 1991) Conversely, water subject to evaporation becomes progressively heavier with increasing evaporation because of the loss of the lighter fraction as water vapor

Surface water also is a source of ground-water recharge in the Carson River Basin Among the different sources of surface water analyzed, streams draining the Carson Range of the Sierra Nevada on the west side of Carson Valley have the lightest stable-isotope composition (fig 8) Carson River water generally had hydrogen-isotope compositions ranging from about -110 to -100 permil in the reach from above Carson Valley (at gages 10309000 and 10308200, fig 1) to above Lahontan Reservoir (gage 10312000) Lahontan Reservoir receives water from both the Carson River and, through the Truckee Canal, from the Truckee River The Truckee River at Tahoe City, which is the outflow from Lake Tahoe, had a distinctly heavier isotopic composition than any other surface water sampled at a higher altitude than Lahontan Reservoir (fig 8) The isotopic composition of water from Lake Tahoe and the Truckee River about 500 ft downstream from Lake Tahoe (gage 10337000, Bostic and others, 1991) is similar Truckee River water near Farad (gage 10346000, Bostic and others, 1991, fig 10) appears to have an isotopic composition largely controlled by the amount of water from Lake Tahoe compared to contributions from other drainages Release of ground water from bank storage also may alter the isotopic composition of Truckee River water (McKenna, 1990)

Tritium is a useful indicator of the "age" of ground water (the time since the water has been out of contact with the atmosphere), which provides information on the hydrogeology of the area Tritium, a radioactive isotope of hydrogen with a half-life of 12 33 years (Friedlander and others, 1981), is part of the water molecule forming precipitation and provides recharge to ground water The tritium content of precipitation is derived from atmospheric releases generated by above-ground thermonuclear explosions beginning in 1952 and cosmic-ray bombardment in the upper atmosphere

Tritium present in precipitation before thermonuclear testing of atomic weapons generally is believed to result (in 1990) in activities less than about 25 pCi/L (picocuries per liter, Fontes, 1980, p 81) If tritium activities in precipitation before 1952 were at a constant value of 25 pCi/L, ground water older than 57 years would have present-day (1990) activities less than about 1 pCi/L Major releases from above-ground testing caused tritium activities in 1990 of more than 10 pCi/L in precipitation since 1952 High tritium activities in ground water (greater than 100 pCi/L) are a result of precipitation in 1958-59 and 1962-69 These periods of high tritium activities are supported by estimated activities in precipitation on the Sierra Nevada in the Lake Tahoe Basin (fig 9, Carl Thodal, U S Geological Survey, written commun , 1991, and on the basis of the tritium deposition model developed by Michel, 1989) Mixing of water with different activities of tritium can produce intermediate values Ages for ground water based on tritium data are interpreted using the following general guidelines

Tritium activities (pCi/L)	Period of recharge		Comments
	Years	Number of years before 1990	
Less than 1	pre-1933	more than 57	--
1 to 10	1933 to 1952	57 to 38	Can be mixture of pre- and post-1952 water
11-100	after 1952	fewer than 38	--
Greater than 100	1958-59, 1962-69	32-31, 28-21	--

Hydrogeology of the Upper Carson River Basin

***By* Donald H Schaefer *and* Alan H. Welch**

The Headwaters Area and the Carson Range are rugged, with extremes of altitude and relief Drainages are typically narrow with steep sides and, in the Headwaters Area, the canyons are more than 1,000 ft deep Main hydrologic features of the Headwaters Area are the East and West Forks of the Carson River and their many tributaries Average annual flow of the West Fork is about 80,000 acre-ft, based on records collected during 59 years between 1900 and 1990 (gaging station 10310000, Bostic and others, 1991, p 137) For the East Fork, average annual flow is about 270,000 acre-ft, based on records collected during 64 years between 1891 and 1990 (gaging station 10309000, Bostic and others, 1991, p 131)

Canyon bottoms of the Headwaters Area are underlain by lenses of stream-deposited boulders, cobbles, and gravel probably no more than a few tens of

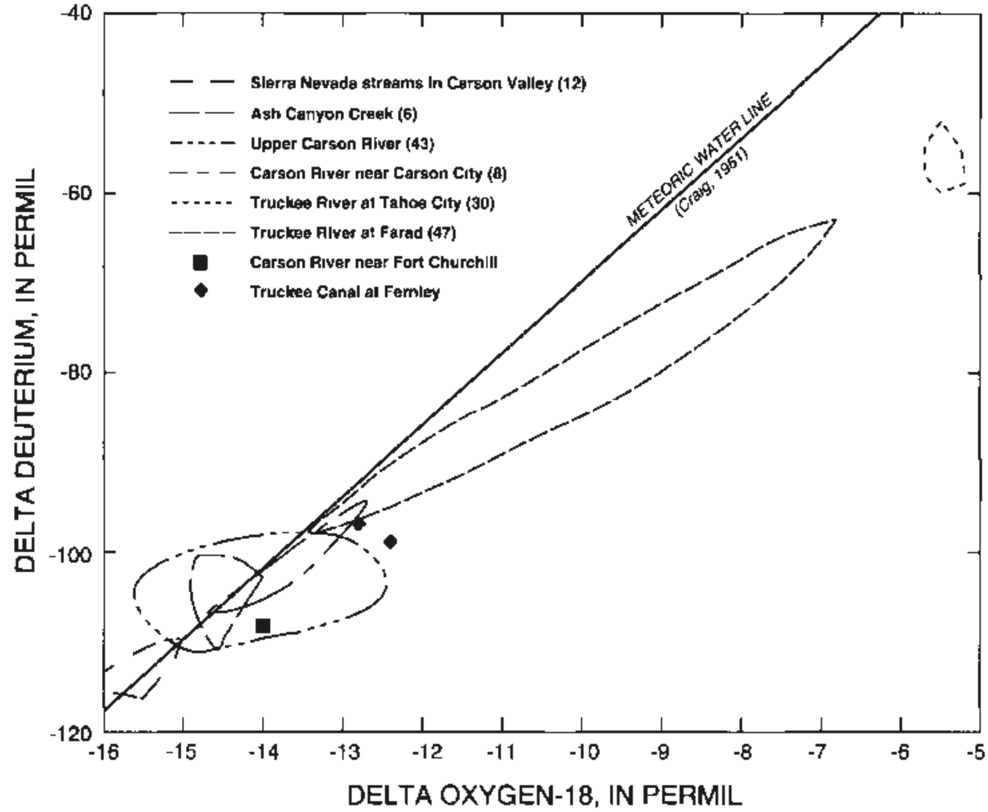


Figure 8. Relation between stable isotopes of hydrogen (deuterium) and oxygen in surface water of Carson and Truckee River Basins, Nevada and California Value in parentheses is number of analyses enclosed by envelope Data are from U S Geological Survey, except for Ash Canyon Creek (Szecsody and others, 1983)

feet thick and generally no more than a few hundred feet wide Ground-water levels in these deposits are controlled by the stage of the adjacent stream

In upland areas, the presence of ground water depends on the permeability of consolidated rocks Permeability is related mostly to the depth of weathering and, beneath the weathered zone, to the degree to which the rocks are fractured Both factors probably differ throughout the area, and the degree to which consolidated rocks are saturated with water and will yield water to wells differs accordingly

Carson Valley is a north-trending basin bounded to the west by the Carson Range, to the east by the Pine Nut Mountains, and to the north by an alluvial divide separating Carson Valley from Eagle Valley The valley floor is underlain by a structural basin as much as 5,000 ft deep along the west side that becomes progressively more shallow to the east (Maurer, 1985, p 5)

The East and West Forks of the Carson River enter Carson Valley at its south end and join near the west margin of the valley floor about 3 mi northwest of Minden Just downstream from this confluence, the river bends and exits the valley at its northeast corner Average annual flow, measured at a gage near Carson City, has been about 290,000 acre-ft during the years from 1939 through 1990 (gaging station 10311000, Bostic and others, 1991, p 143) Other surface-water features include several small streams in the Carson Range and the Pine Nut Mountains, sloughs and abandoned channels of the river, and a network of irrigation ditches and drains

Older, Tertiary-age basin-fill deposits in Carson Valley reach thicknesses of 1,000 ft or more on the east side of the valley (Moore, 1969, p 12, Maurer, 1986, p 12) Dipping westward beneath younger deposits, the older deposits underlie the central valley Younger deposits are mostly fluvial gravels that attain thicknesses up to 50 ft (Moore, 1969, p 14, 15) These younger deposits overlie the older deposits along the east side of the valley Youngest deposits form alluvial fans next to mountains and extensive areas in the Carson River flood plain (Moore, 1969, pl 1)

The ground-water basin in Carson Valley contains two discontinuous confined alluvial aquifers (Maurer, 1985) and a shallow water-table aquifer Aquifers are confined in alluvial fans along the west margin of the valley and in basin-fill deposits beneath the central part of the valley Contours show the altitude of the water table (pl 1) Contours indicate ground-water movement is toward the Carson River from both sides of the valley, and then generally northward through sediments beneath the river A water-table aquifer is hydraulically connected to the river throughout most, if not all, of the valley Water moves between the river and aquifer in either direction, depending mostly on the stage of the river

Many features of the ground-water system in Carson Valley can be visualized by examining ground-water flow along an east-west line at the latitude of Gardnerville (fig 10), derived from a description by Welch (1994) Precipitation on the Carson Range is an important source of recharge to upland aquifers Ground-water flow in the upland areas is largely restricted to fractures in the shallow subsurface and faults Flow from upland aquifers in the Carson Range recharges the basin-fill sediments and then flows north and east

Basin-fill sediments include lacustrine clays, deposits formed by through-flowing river water, and alluvial fan deposits Fan deposits generally form at the mouths of canyons at the base of the Carson Range Much, if not all, surface water flowing across these fans recharges the basin-fill sediments Away from canyons, the bedrock sides of basin-bounding faults are exposed and fans are small or absent This setting is shown in figure 10 Through-flowing rivers formed both permeable channel sediments (sand and gravel) and less-permeable flood-plain deposits (clay and silt) Structural tilting of the basin to the west has probably displaced rivers to the west As a result of tilting, a greater proportion of the channel deposits is in the western than in the eastern basin-fill sediments

Laterally extensive clay deposits restrict vertical movement of ground water in the basin-fill sediments The lateral extent of the clay deposits is consistent with deposition of lacustrine sediments These deposits are not continuous (Douglas K Maurer, U S Geological Survey, oral commun ,1992) The lack of lateral continuity may be a result of erosion by through-flowing surface water after deposition Replacement of clay

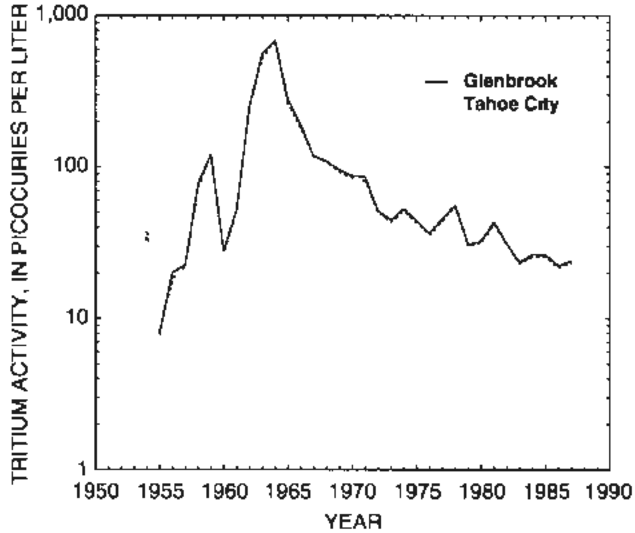


Figure 9 Estimated 1990 tritium activities in 1953-86 precipitation on uplands of Truckee River Basin, Nevada and California

deposits by more permeable fluvial sediments allows much of the vertical movement of water between zones above and below the clay deposits (inset *B* of fig 10)

Shallow basin-fill aquifers are recharged by flow from upland aquifers, surface water diverted for irrigation, and the Carson River Most irrigation water returns to the Carson River either as ground-water discharge or hy way of drainage ditches (inset *A* of fig 10) Recharge of deeper aquifers through shallow basin-fill sediments is enhanced by hydraulic gradients created by pumping and by flow through breaches in laterally extensive clay deposits (inset *B* of fig 10)

The structural basin beneath Eagle Valley consists of several north-northeast-trending fault blocks (Arteaga, 1982, p 26) Fault scarps in the basin-fill deposits approximately coincide with margins of these fault blocks The basin has a maximum depth of about 2,800 ft beneath the eastern part of the valley (Arteaga, 1982, p 26)

Eagle Valley has a shallow water-table aquifer and one or more deeper alluvial aquifers (Arteaga, 1982, p 8) Confining beds are composed of discontinuous clay lenses at different depths Confined conditions are most pronounced where ground-water flow paths from the north, northwest, and southwest converge Water-level altitudes shown on plate 1 are based on measurements at shallow wells in some areas, and at deeper wells in others Therefore, the altitudes shown do not necessarily represent the water table, instead, they are a composite potentiometric surface that represents confined conditions in some areas

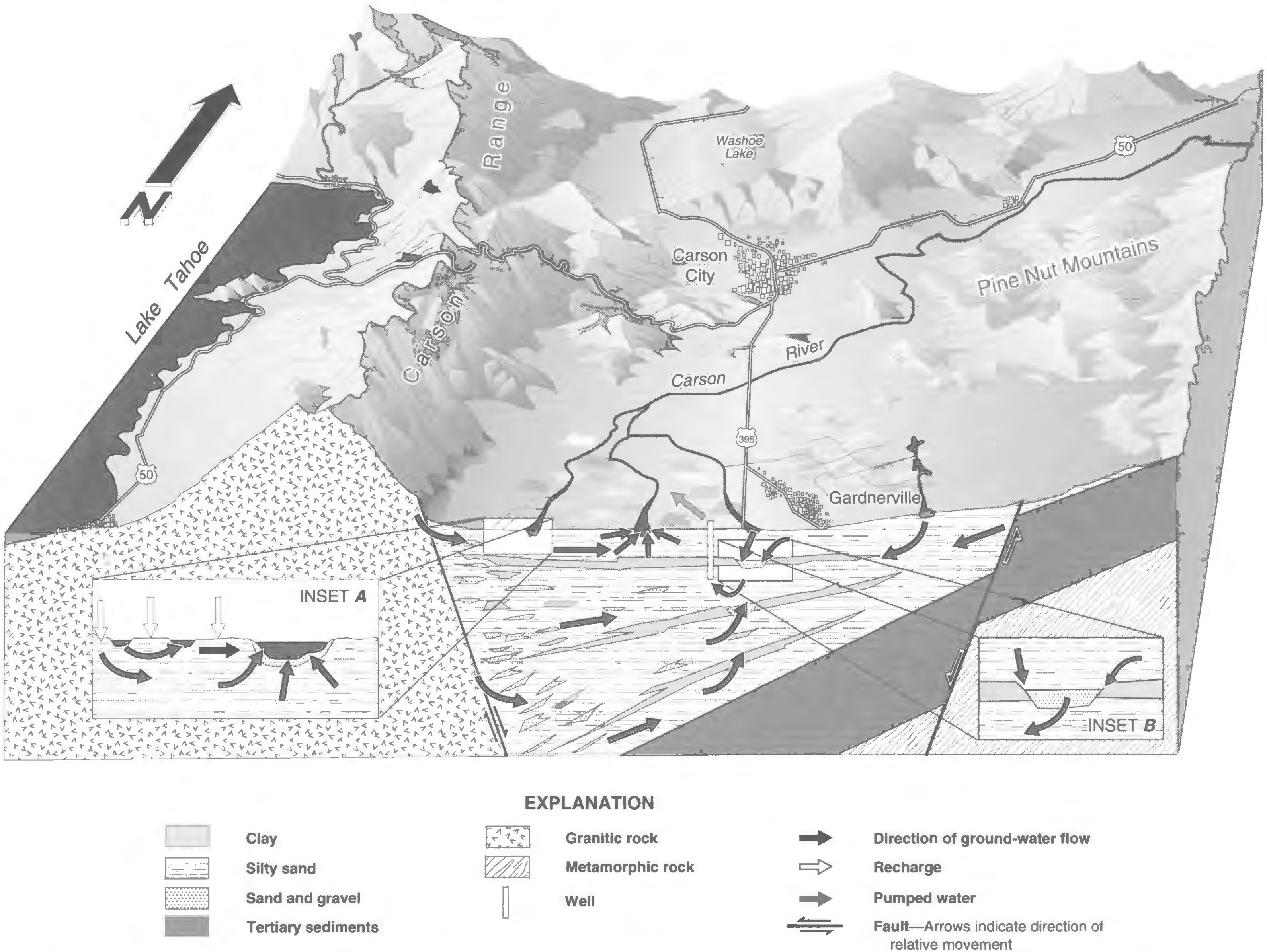


Figure 10. Schematic three-dimensional "block diagram" showing geology and ground-water flow in Carson Valley, Nevada and California. Inset *A* shows shallow ground-water recharge and discharge; inset *B* shows downward movement through buried channel deposits.

Though ground-water movement is complex because of several consolidated-rock barriers, the movement is generally toward the Carson River

Most recharge to principal aquifers in Eagle Valley comes from runoff and underflow along the west side of the valley and infiltration of streamflow and irrigation water elsewhere Ground water discharges from the basin as evapotranspiration, by pumping, and as subsurface underflow to Carson Valley and the Carson River The easternmost part of Eagle Valley is along the flood plain of the Carson River Although this part of the valley is formally part of the Dayton Valley hydrographic area, it is hydrologically connected to Eagle Valley and discussed as part of the upper Carson River Basin in this report This area is a small structural basin filled with sediment as much as 800 ft thick (Arteaga, 1982, p 26) Sediments in this small basin consist of poorly sorted silty gravels and sands of alluvial fans and pediments along basin margins and silt and sands of the Carson River flood plain (Bingler, 1977)

Recharge to this small basin is provided by underflow eastward from Eagle Valley Ground water is discharged by wells, seepage into the Carson River, and by evapotranspiration The Carson River gains about 1,500 acre-ft/yr of ground-water discharge in its reach through this area (Arteaga and Durbin, 1978, p 32), much of which is from the west In contrast, the river probably acts as a source of recharge during high flow Pumping of municipal wells next to the river, beginning in the late 1980's, may be inducing recharge from the river

A major control on the stable-isotope composition of ground water in basin-fill sediments of Carson and Eagle Valleys is the composition of recharge In Carson Valley, hydrogen-isotope compositions of the major sources of recharge are -110 to -98 permil for the Carson River, -118 to -98 permil for precipitation and precipitation runoff in the Carson Range of the Sierra Nevada (fig 11), and -128 to -122 permil for precipitation and precipitation runoff in the Pine Nut Mountains (estimated by Welch, 1994)

The source of recharge to shallow and principal aquifers in Carson Valley may be inferred from relations between the hydrogen-isotope composition of the ground water and of recharge Water from shallow wells (water levels less than 50 ft below the land surface) in agricultural areas generally has an isotope composition within the range of Carson River water, which is the source of most water used for irrigation This similarity in the hydrogen-isotope composition indicates the Carson River is an important source of recharge to shallow aquifers Local exceptions may be caused by infiltration of treated sewage water imported from the Lake Tahoe Basin or upward flow from principal aquifers

Most ground-water samples from Carson Valley contain at least some water recharged since about 1952, as indicated by tritium activities equal to or greater than 10 pCi/L Ground water in principal aquifers in the Minden-Gardnerville area is withdrawn by large-capacity wells used for irrigation and municipal supply Water in this area has stable hydrogen-isotope compositions within the range found for the Carson River and tritium activities equal to or greater than 10 pCi/L (fig 12) Taken together, the stable hydrogen-isotope composition and tritium data for this area indicates that the Carson River is a major source of recharge to principal aquifers Pumping of the large-capacity wells has created a downward component of flow, recharging principal aquifers in this area

Ground water beneath northwest Carson Valley generally has tritium activities less than 10 pCi/L and hydrogen-isotope compositions lighter than -110 permil (fig 12) These values suggest precipitation in the Carson Range entered the ground-water system more than 38 years before present (1990)

Stable-isotope composition of ground water in principal aquifers beneath much of Eagle Valley generally is similar to the composition of water in upland aquifers of the mountains to the west Water in Ash Canyon Creek and the upland aquifers is considered representative of water in the mountains Wells tapping principal aquifers along surface-water drainages and beneath an irrigated park yield water with slightly heavier hydrogen-isotope compositions Heavier compositions are most likely caused by evaporation affecting the water before recharge Isotope composition of ground water in northeastern Eagle Valley also is lighter than Ash Canyon Creek This lighter composition is due to a lighter stable-isotope composition in precipitation in the recharge area to the northeast than in precipitation in the Carson Range Tritium activities in principal aquifers of Eagle Valley of generally less than 1 pCi/L, except along the margins of the basin-fill deposits (fig 13), indicate the water was recharged at least 57 years ago

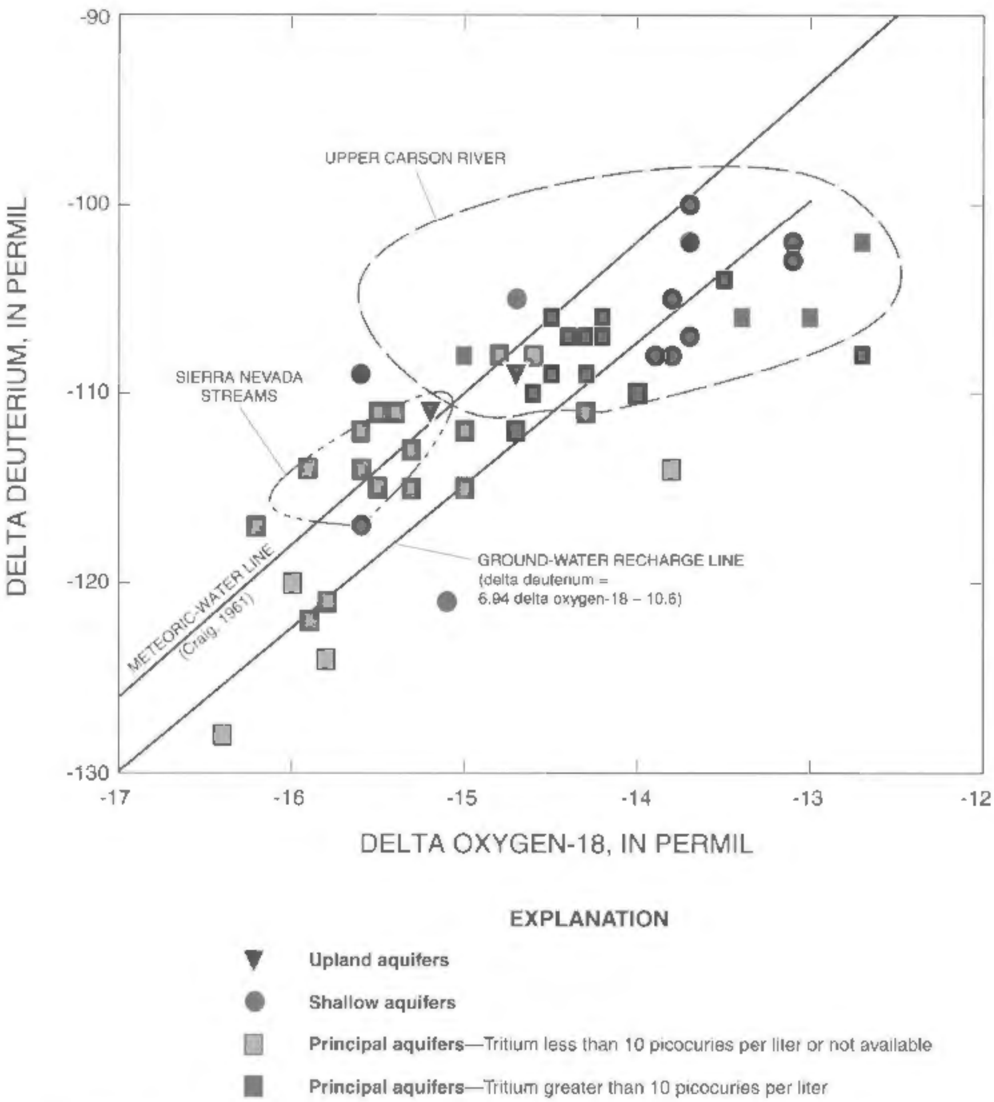


Figure 11. Relation between stable isotopes of hydrogen (delta deuterium) and oxygen in ground water of Carson Valley, Nevada and California.

Hydrogeology of the Middle Carson River Basin

***By* Donald H. Schaefer *and* James M. Thomas**

The Dayton Valley hydrographic area includes several basins extending from Eagle Valley to Churchill Valley (pl. 1). One of these is Carson Plains, a valley east of the town of Dayton. Carson Plains also includes a narrow strip of river flood plain and uplands of the Pine Nut Mountains south of Stagecoach Valley. Maximum thickness of basin-fill deposits, on the basis of geophysical modeling, is about 3,000 ft (Schaefer and Whitney, 1992).

A structural basin underlying Stagecoach Valley contains as much as 3,000 ft thickness of fill on the east side and as much as 1,000 ft on the west side (Schaefer and Whitney, 1992). Basin-fill deposits in Stagecoach Valley consist of poorly sorted deposits of alluvial fans and pediments extending from mountain fronts toward valley lowlands. Valley lowlands are underlain by fine playa deposits formed, at least in part, by lacustrine sediments of Pleistocene Lake Lahontan. Flood-plain deposits are restricted to a narrow strip south of and along the south bank of the Carson River.

Depths to water in Carson Plains range from less than 20 ft near the Carson River to 100-200 ft on fan slopes away from the river (Glancy and Katzer, 1976,

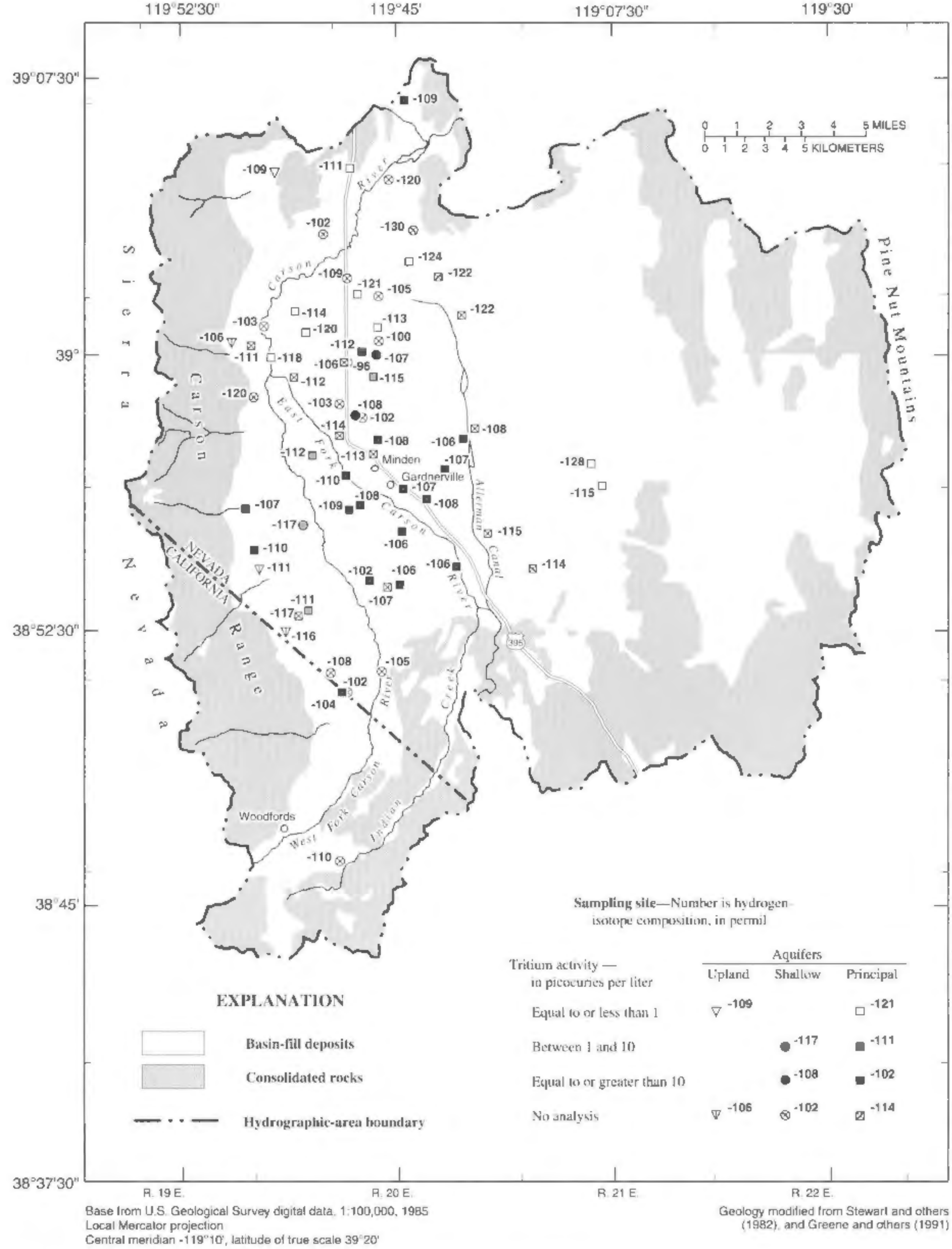
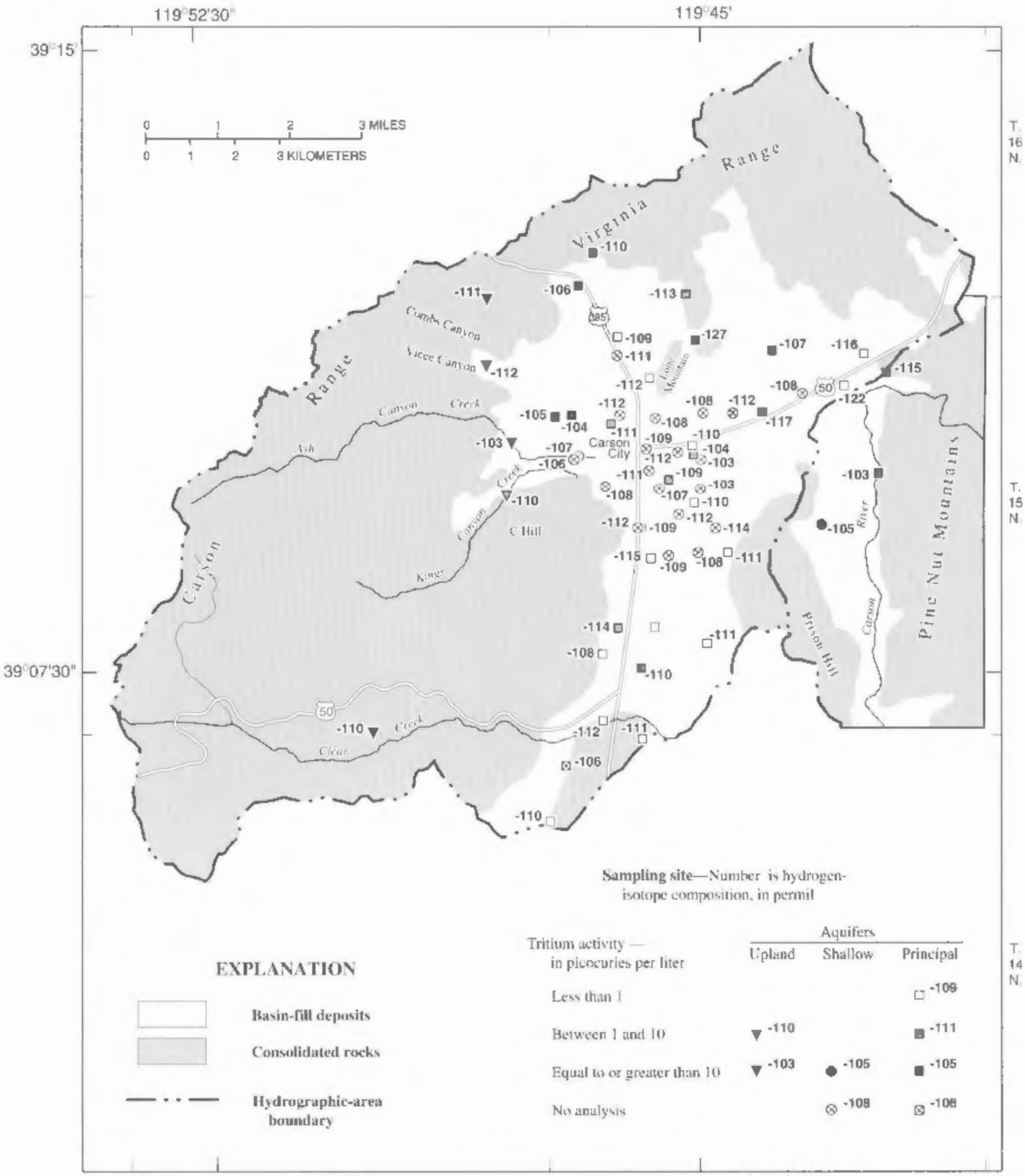


Figure 12. Hydrogen-isotope composition of ground water in Carson Valley, Nevada.



Base from U.S. Geological Survey digital data, 1:100,000, 1985
Local Mercator projection
Central meridian -119°10', latitude of true scale 39°20'

Geology modified from Greene and others (1991)

Figure 13. Hydrogen-isotope composition of ground water in Eagle Valley, Nevada.

p 104) Average depth to water is about 60 ft (Schaefer and Whitney, 1992) Ground water generally moves eastward through the valley, as shown by water-level contours (pl 1) Aquifers are recharged by precipitation in the Virginia Range and Pine Nut Mountains, and discharged by withdrawals from wells and evapotranspiration Shallow aquifers near the Carson River are recharged by diversions from the Carson River During high flow, the river also can be a source of recharge Discharge from shallow aquifers to the river probably occurs during some periods of low flow in the Carson River

Water levels in Stagecoach Valley indicate shallow ground water moves eastward and southward through basin-fill deposits (pl 1) Precipitation provides recharge in the Virginia Range to the north and by inflow from the Carson River flood plain in the east part of the Carson Plains Evidence for inflow is supported not only by contours of water-level altitudes in Stagecoach Valley, but also by stable-isotope composition of the ground water (Harrill and Preissler, 1994) Aquifers in Stagecoach Valley are discharged by pumping, evapotranspiration on the valley floor, outflow to the river through basin fill, and possible outflow to Churchill Valley through the alluvial divide separating the two valleys

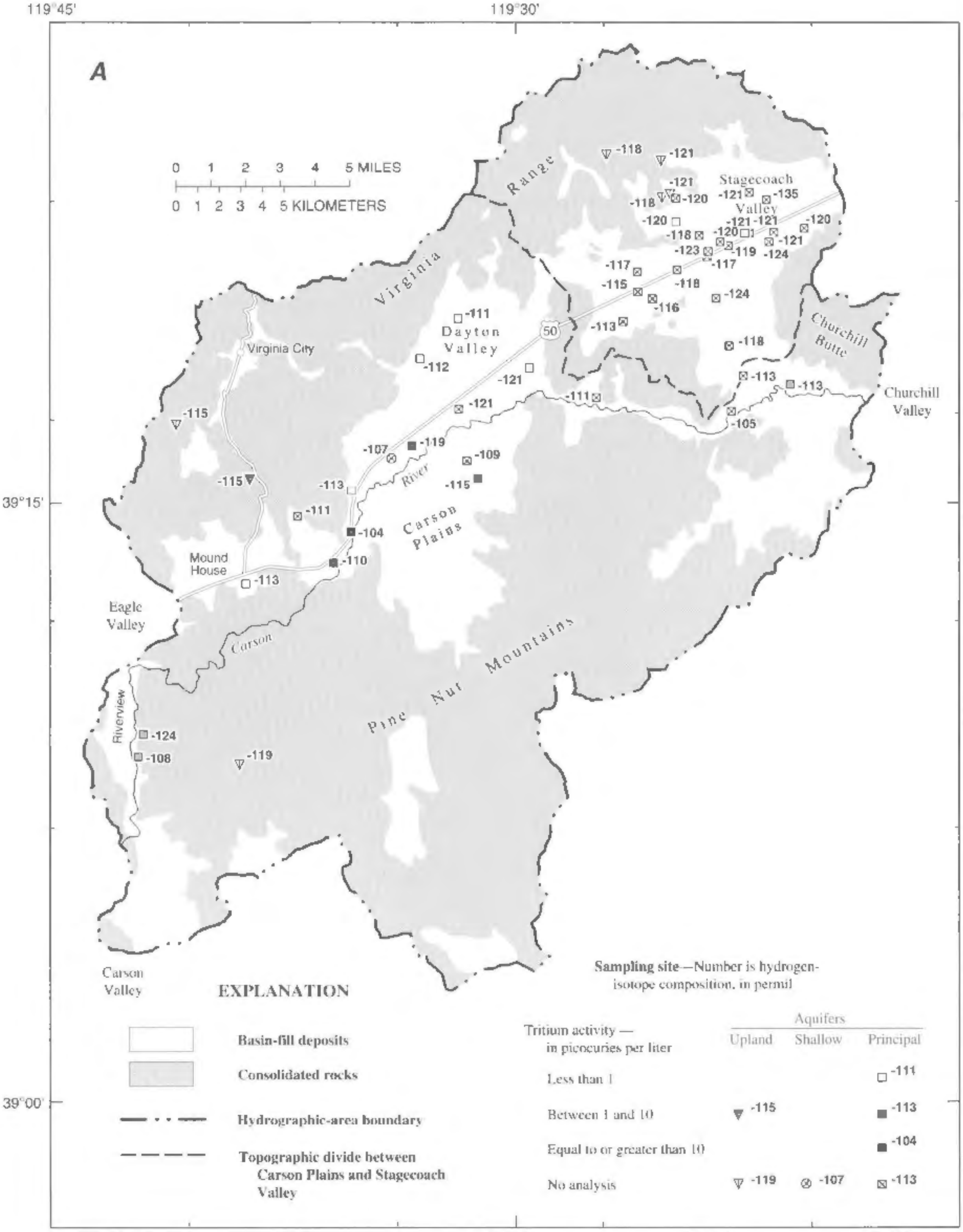
Churchill Valley trends northeast and is bounded by mountains (pl 1) The Carson River enters the west side of the valley south of Churchill Butte (fig 14*A*) Before the construction of Lahontan Dam, the river flowed out of the valley through a canyon, now buried, in the Dead Camel Mountains (fig 14*B*) Average annual flow of the Carson River into the valley was about 268,000 acre-ft/yr for 1911-90 (gaging station 10312000, Bostic and others, 1991, p 150) Another 145,000 acre-ft/yr was diverted into Lahontan Reservoir from the Truckee River by way of the Truckee Canal during 1966-90 (gaging station 10351400, Bostic and others, 1991, p 275)

Thicknesses of basin-fill deposits in Churchill Valley reach a maximum of about 2,900 ft, as shown by gravity and magnetic data (Schaefer and Whitney, 1992) Logs for two domestic wells in the northwest and north-central parts of the valley show depths to consolidated rock of 300 ft and 210 ft, respectively In addition, andesite crops out near the center of the valley On the basis of geophysical data, the andesite appears to cap metavolcanic and sedimentary rocks extending from Churchill Butte (Schaefer and Whitney, 1992)

Ground-water levels beneath Churchill Valley range from 20-50 ft or less below land surface near the shores of Lahontan Reservoir and the Carson River flood plain to more than 200 ft near the margins of the alley (Glancy and Katzer, 1976, p 105) Directions of ground-water movement are southward toward the river flood plain and eastward toward Lahontan Reservoir (pl 1, Schaefer and Whitney, 1992) that now covers much of an earlier flood plain Ground-water recharge to the valley is an estimated 1,300 acre-ft/yr (Glancy and Katzer, 1976, p 48) and comes from precipitation in surrounding mountains and infiltration from the river and reservoir Discharge of ground water is primarily by withdrawal from wells and evapotranspiration

On the basis of geographic location, stable hydrogen-isotope composition, and limited tritium analyses, ground water in principal aquifers of Dayton and Churchill Valleys can be separated into two groups One group consists of ground water in principal aquifers of Dayton and Churchill Valleys away from the river Ground water in this group has stable hydrogen-isotope compositions similar to ground water in adjacent mountains Tritium activities in ground-water samples were less than 1 pCi/L, except in a sample from one well in an alluvial fan in Dayton Valley (fig 14*A*) The other group, which has hydrogen-isotope compositions heavier than ground water in the adjacent principal aquifers (fig 15) and tritium activities greater than 1 pCi/L, is near the Carson River (fig 14) Because the hydrogen-isotope composition in this group is similar to the Carson River, or is between that of the Carson River and ground water in the adjacent principal aquifer, and because of the apparent relatively young age, a major source of recharge probably is the river This recharge can be either directly from the river, especially during high streamflow, or from diversions for irrigation Local subsurface flow of river water into principal aquifers in southwestern Stagecoach Valley also is indicated by general ground-water quality, water-level contours, and a water-budget imbalance (Harrill and others, 1992)

The hydrogen-isotope composition of ground water in principal aquifers away from the Carson River in Dayton and Churchill Valleys becomes distinctly heavier proceeding west (fig 16) Deuterium content of



Base from U.S. Geological Survey digital data, 1:100,000, 1985
Local Mercator projection
Central meridian -119°10', latitude of true scale 39°20'

Geology modified from Greene and others (1991)

Figure 14. Hydrogen-isotope composition of ground water in (*A*) Dayton and (*B*) Churchill Valleys, Nevada.

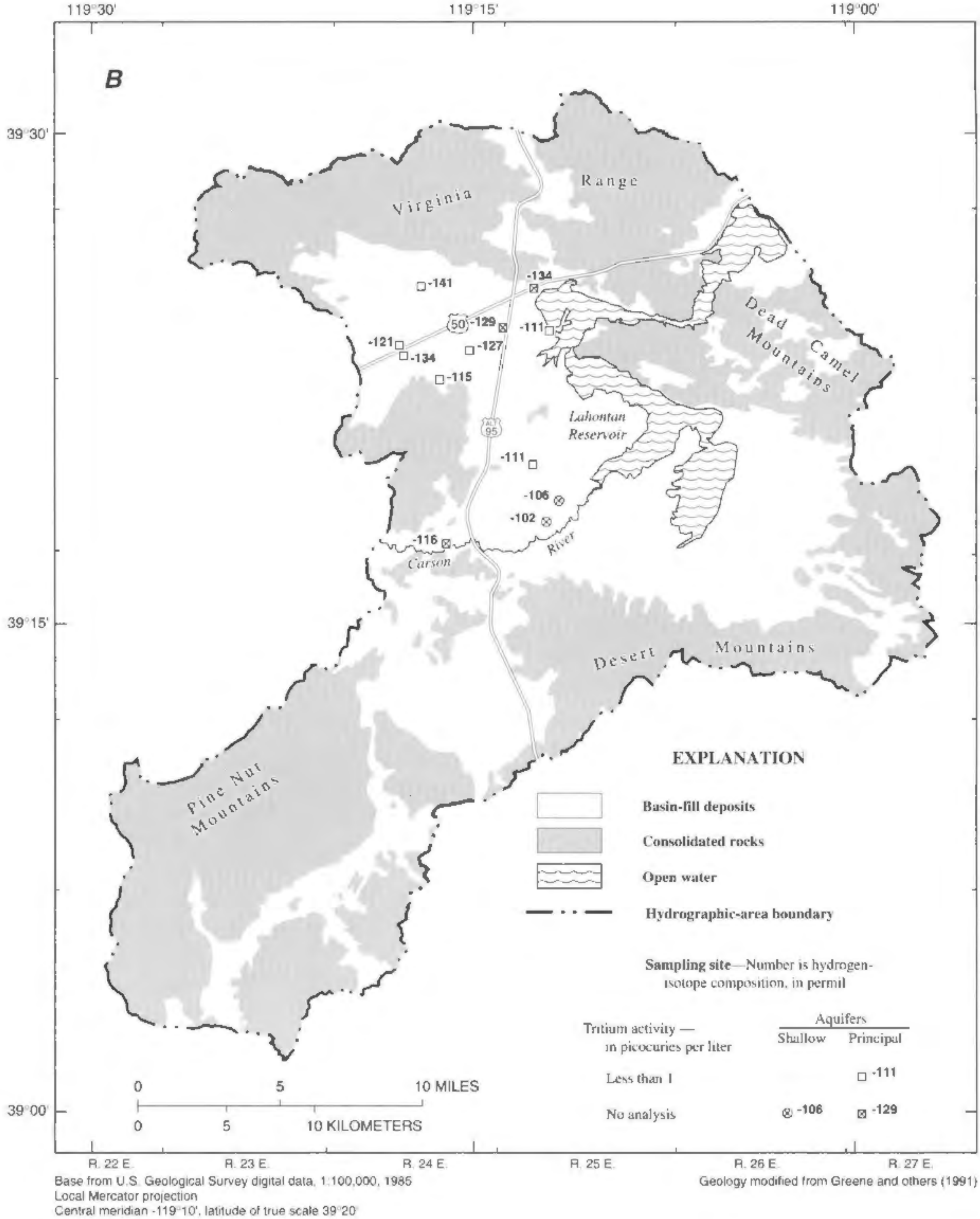


Figure 14. Continued.

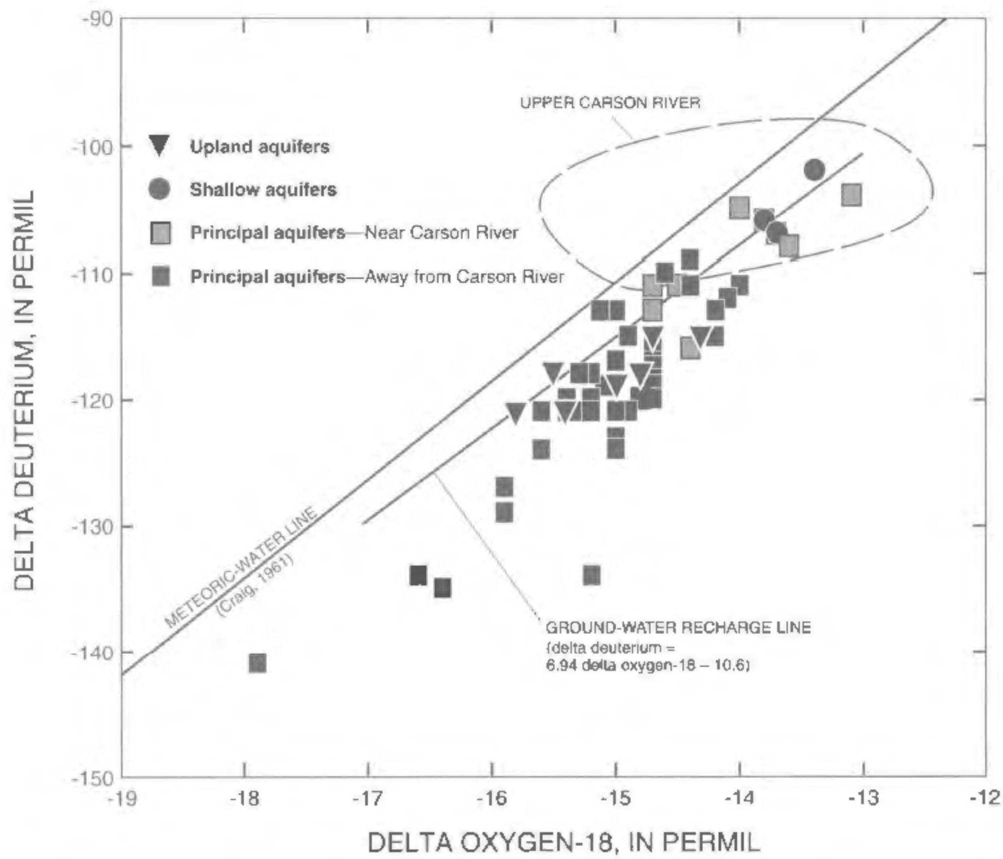


Figure 15. Relation between stable isotopes of hydrogen (delta deuterium) and oxygen in ground water of Dayton and Churchill Valleys, Nevada.

ground water in principal aquifers of Dayton and Stagecoach Valleys generally is similar to ground water in the adjacent Virginia Range and Pine Nut Mountains (fig. 14*A*). Due to a lack of available sampling sites, the stable-isotope composition of water in upland aquifers in Churchill Valley is not known. Primary sources of ground water in Churchill Valley north of the Carson River are precipitation on the Flowery Range to the north along with ground-water flow from Stagecoach Valley. Absence of tritium in wells in basin-fill aquifers away from the Carson River, suggests that the water was recharged more than 57 years ago. This conclusion is supported by the absence of irrigation away from the river, except limited irrigation by ground water in Stagecoach Valley (Welch and others, 1989).

Hydrogeology of the Lower Carson River Basin

***By* Donald H. Schaefer *and* Michael S. Lico**

Carson Desert, the largest valley in the Carson River Basin, is elongate northeastward, and has a maximum length of about 70 mi and a maximum width of about 25 mi (pl. 1). The basin is the terminus of the Carson River, which enters the basin just below Lahontan Dam. Average flow of the river below the dam, including Truckee River water diverted to Lahontan Reservoir by way of the Truckee Canal, was about 390,000 acre-ft/yr for 1966-90 (gaging station 10312150; Bostic and others, 1991, p. 154). Most of the Carson River flow is diverted for irrigation in the Fallon area. The rest, along with irrigation returns, flows to sinks and lakes in the Desert. Carson Sink is a large salt flat during years of average or below-average precipitation, but during wet years it becomes a large shallow lake that receives water from the Carson River, from irrigation runoff, and by occasional overflow from the Humboldt River Basin north of the sink.

Carson Desert consists of several smaller structural basins, some of which are oriented along regional structural trends. Northern Carson Desert is underlain by a northeast-trending structural basin along the West Humboldt Range that is 6,000 ft deep, and by a north-trending trough along the Stillwater Range that is 12,000 ft deep. A northeast-trending bedrock high

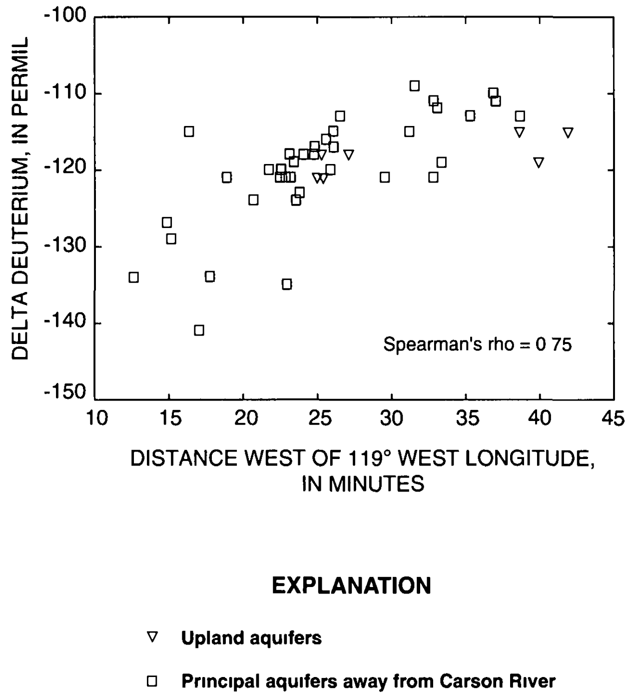


Figure 16. Relation between the hydrogen-isotope (delta deuterium) composition of ground water and longitude in Dayton and Churchill Valleys, Nevada

at a depth of about 2,000 ft separates the two smaller basins (Hastings, 1979, p 518) Unpublished gravity data indicate a deep basin underlying the southern part of the desert, where an exploration hole penetrated more than 8,000 ft of basin-fill deposits without reaching bedrock (Garside and others, 1988)

Lacustrine, fluvial, and wind-blown sediments and interbedded volcanic rocks form the basin-fill deposits beneath the desert. The upper 2,000-3,000 ft of the basin-fill deposits are mostly sediments and include lesser amounts of volcanic rocks Deeper parts of the basin-fill deposits have increasingly greater proportions of volcanic rocks (Franklin H Olmsted, U S Geological Survey, written commun , 1987)

The ground-water system in Carson Desert is the most complex in the Carson River Basin It has been investigated in the southern Carson Desert (Glancy, 1986) and in geothermal areas (Morgan, 1982, Olmsted and others, 1984, Olmsted, 1985) Shallow, intermediate, and deep alluvial aquifers and a basalt aquifer underlie the southern area (Glancy, 1986) The basalt aquifer is the source of water for the municipal water supply for Fallon and the Fallon Naval Air Station, shallow and intermediate aquifers provide water to domestic wells and to some irrigation wells

Discussion of the ground-water quality in Carson Desert is based on the aquifer designations of Glancy (1986) The shallow aquifer system includes ground water at depths less than 50 ft below land surface The intermediate aquifer system includes ground water in sediments at depths between 50 and about 320 ft below land surface The basalt aquifer crops out at Rattlesnake Hill The term "principal aquifers," when applied to the Carson Desert, refers to the intermediate and the basalt aquifer systems

Directions of ground-water flow in shallow aquifers generally are northeastward and eastward toward the Carson Sink (pl 1) Directions of movement in intermediate basin-fill aquifers are similar Flow directions in the basalt aquifer are uncertain because gradients are nearly horizontal (Glancy, 1986, p 15-16) Vertical gradients between the different aquifers indicate upward movement of ground water in some parts of the Carson Desert and downward movement in other parts (Glancy, 1986, p 27, 55) In addition, short-term reversals of vertical gradients in shallow aquifers have been documented (Olmsted, 1985, p 15-19)

Some important features of the ground-water system in southern Carson Desert are shown (view is to the north) in figure 17 Recharge under current conditions is supplied largely by seepage from irrigation canals, the Carson River and its distributary channels, and flood irrigation (Glancy, 1986, p 39) Other sources include locally ponded precipitation in low-lying areas after intense storms (Olmsted, 1985, p 25) and precipitation in mountains surrounding the basin Before irrigation, most recharge probably was supplied by subsurface flow from the Carson River At that time, the depth to the water table was greater in areas away from the river and in low-lying areas, such as Carson Lake Pre-irrigation measurements of depth to water (Stabler, 1904) and the altitude of water in Soda Lake (Rush, 1972) are consistent with this description

Ground-water flow in the basin-fill sediments is affected by laterally extensive lake deposits Fine-grained lake sediments retard vertical movement, except where subsequent erosion has cut through the deposits Channel deposits of the ancestral Carson River generally are more permeable than the enclosing sediments Greater permeability leads to greater ground-water flow, both vertical (fig 17) and horizontal, in these sediments Horizontal movement of ground water is greater in the basalt aquifer than in equivalent thicknesses of the surrounding sediments because of its greater hydraulic conductivity In general, hydraulic

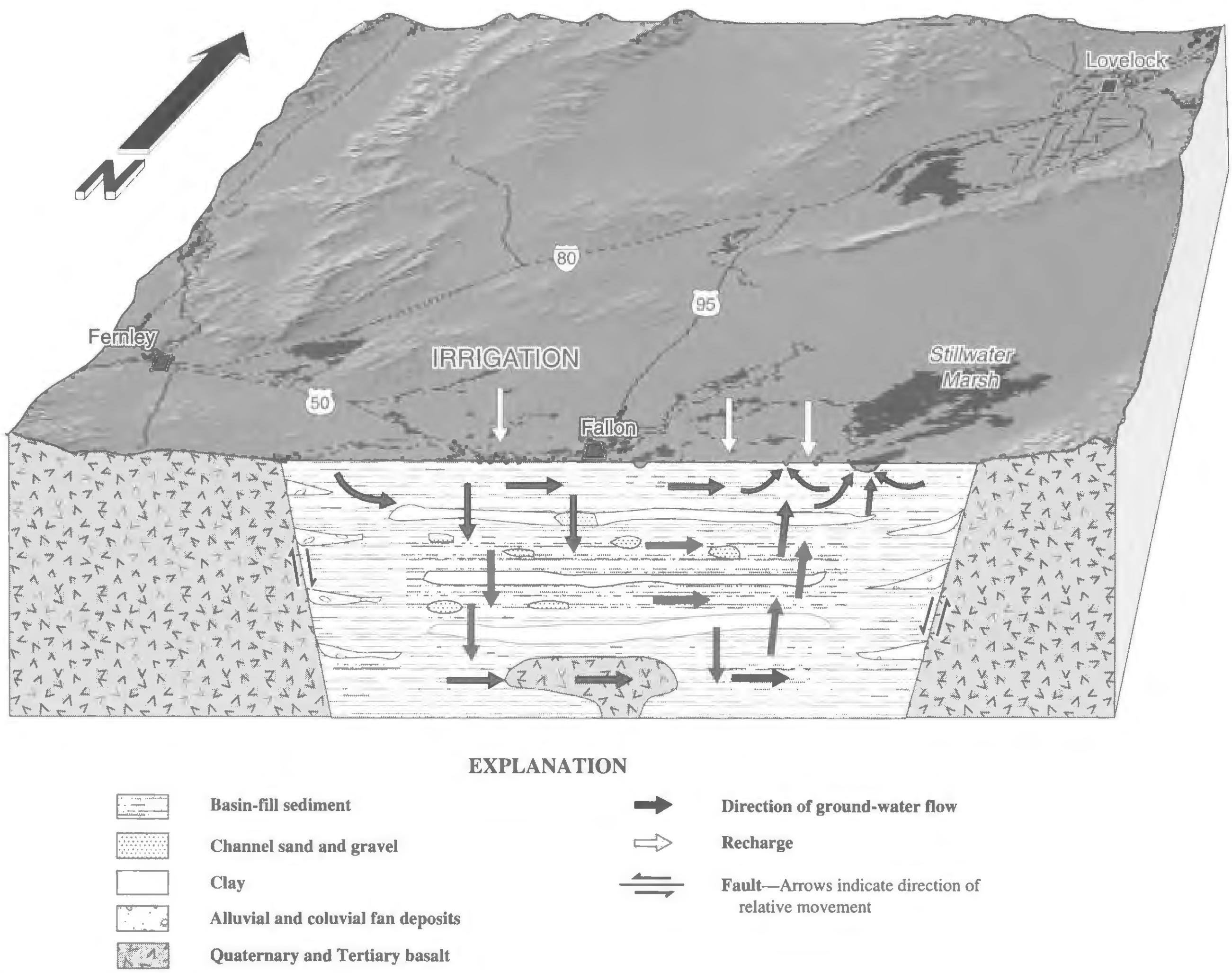


Figure 17. Schematic three-dimensional "block diagram" showing geology and ground-water flow in southern Carson Desert, Nevada.

heads decrease with depth in the recharge area to the west resulting in downward movement of ground water. In discharge areas, on the east side of the southern Carson Desert, ground water tends to move upward (fig. 17).

Irrigation drains and unlined canals control movement of ground water in shallow aquifers beneath irrigated areas (fig. 18). Flood irrigation and leakage from irrigation canals provide water to shallow aquifers. Water levels can rise to land surface during flood irrigation, then decline as water flows into drains that direct the water to Carson Pasture and Stillwater Marsh. Ground water in shallow aquifers is largely from surface sources, except in the low areas of intense evapotranspiration, such as Carson Lake and Stillwater Point Reservoir. Shallow aquifers beneath low areas receive flow from the underlying intermediate aquifers (fig. 17).

The stable-isotope composition of water in shallow aquifers is a result of the water's origin and subsequent isotopic fractionation caused by evaporation. The areal distribution of deuterium shows that less negative values (heavier water) correspond to areas where ground water discharges from shallow aquifers (fig. 19). The composition of this water (fig. 20) is a result of evaporation at the water table of water that moved upward from intermediate aquifers.

The diverse origins of the water result in different stable-isotope compositions. The water from the Carson and Truckee Rivers and water rising from

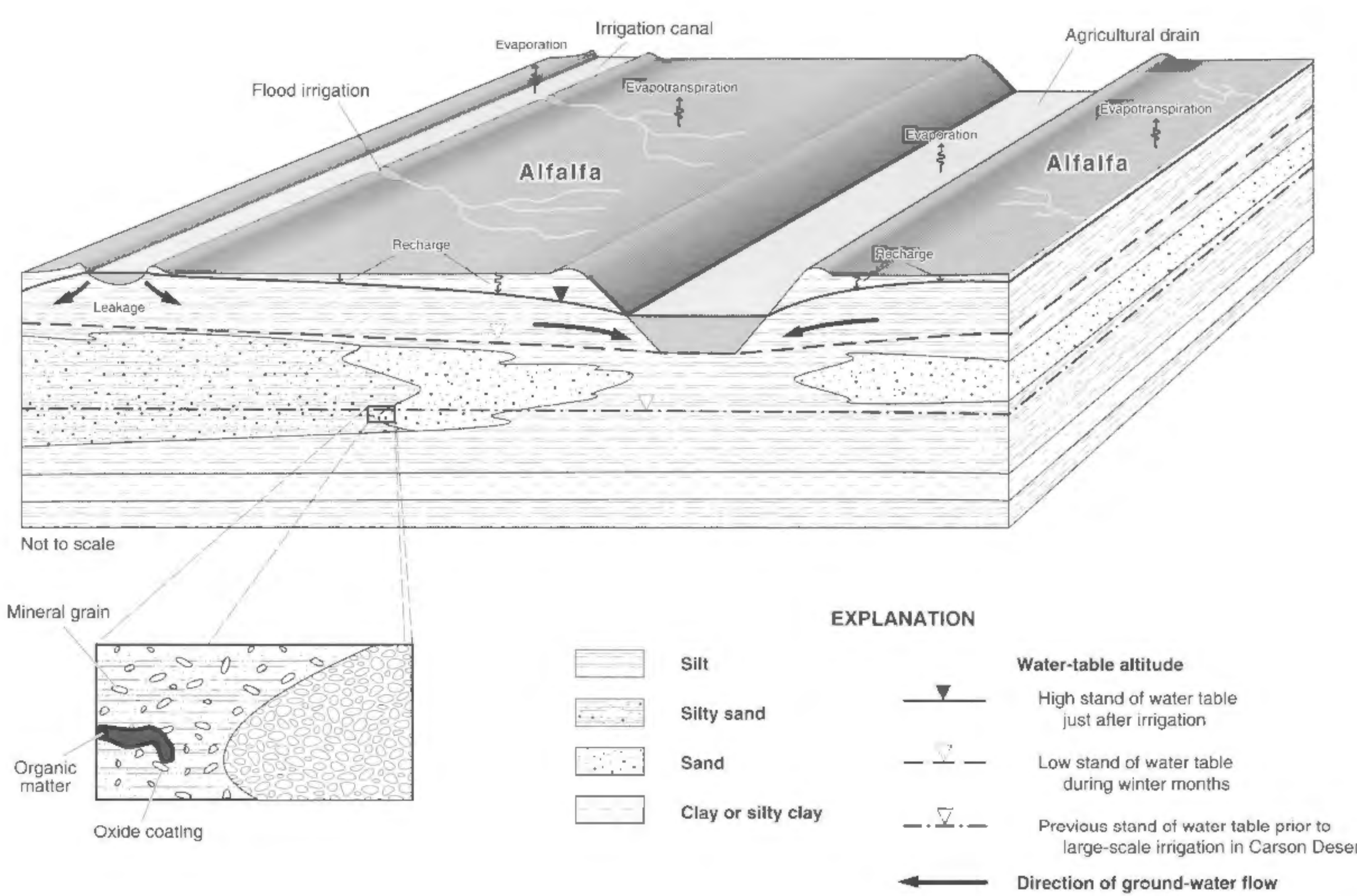
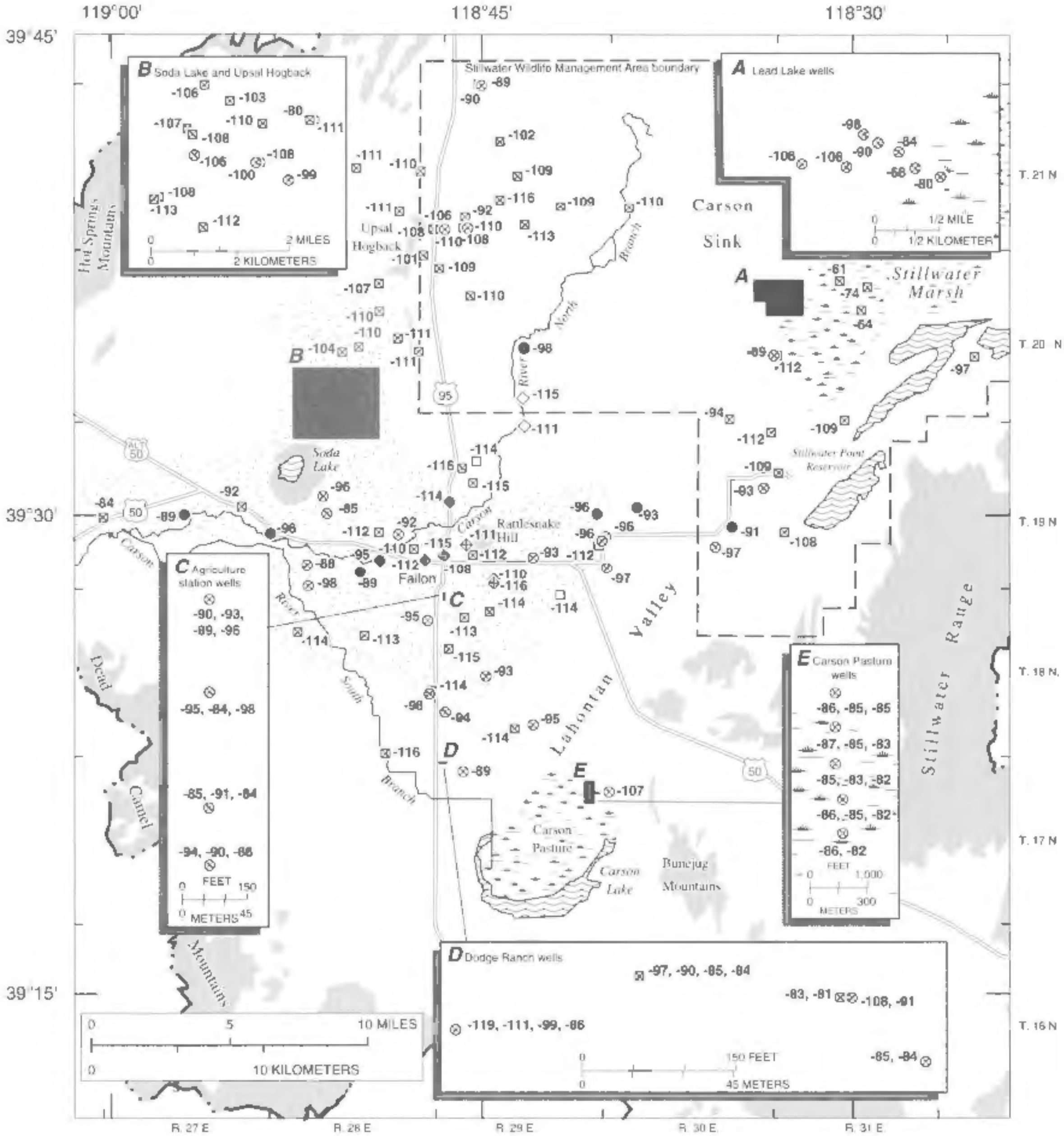


Figure 18. Schematic three-dimensional "block diagram" showing generalized hydrology and hydrogeologic processes affecting the chemistry of water in shallow aquifers of southern Carson Desert, Nevada.



Base from U.S. Geological Survey digital data, 1:100,000, 1985
Local Mercator projection
Central meridian -119°10', latitude of true scale 39°20'

Geology modified from Willden and Speed (1974), and Greene and others (1991)

EXPLANATION

Basin-fill deposits—Pattern indicates generalized area where water levels are higher in shallow aquifer than in intermediate aquifer (modified from Glancy, 1986, p. 55)

Consolidated rocks

Hydrographic-area boundary

Sampling site—Number is hydrogen-isotope composition, in permil. Sites with multiple values are for water from wells drilled at the same location but open to different depths

Tritium activity—in picocuries per liter	Aquifers: Shallow	Aquifers: Intermediate	Aquifers: Basalt
Less than 1		-114	-108
Less than 10			-111
Equal to or greater than 10	-96		
No analysis	-110	-112	-116

Figure 19. Hydrogen-isotope composition of ground water in southern Carson Desert, Nevada.

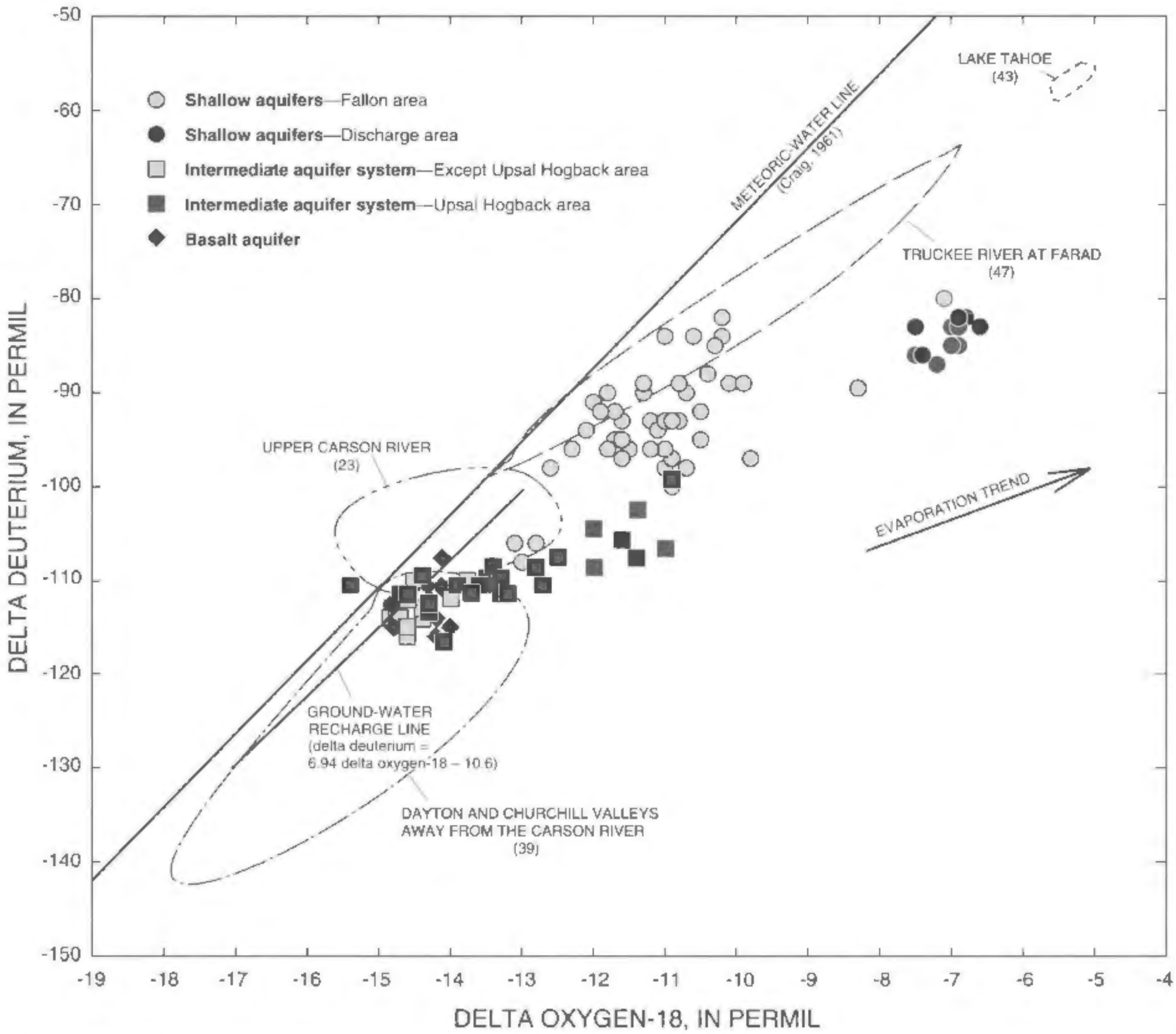


Figure 20. Relation between stable isotopes of hydrogen (delta deuterium) and oxygen in ground water of southern Carson Desert, Nevada. Value in parentheses is number of analyses enclosed by envelope.

intermediate aquifers is subsequently affected by evaporation. The composition of the irrigation water is not constant because it includes varying amounts and compositions of water diverted from the Carson and Truckee Rivers and undergoes varying degrees of evaporation before recharge. The measured range in composition of Carson and Truckee River water is shown in figure 20. Water in shallow aquifers beneath irrigated areas had tritium activities ranging from 39 to 93 pCi/L (table 5). These concentrations suggest recent recharge of surface water.

Most water in basalt and intermediate aquifers near Fallon is isotopically lighter than present-day Carson and Truckee Rivers. Thus, present-day river water alone cannot be the source of water in these aquifers. Recharge for the basalt and intermediate aquifers can be from several sources. Mixing of Carson River water with water having a lighter composition could produce the observed ground water. An isotopically lighter source of water is in Churchill Valley, where a hydrogen-isotope composition as light as -141 permil was measured in ground water (fig. 15). A mixture consisting of about 84 percent river water (with a hydrogen-isotope composition of -110 permil) and about 16 percent ground water (the lightest water measured in Churchill Valley) would have an isotopic composition of -115 permil. This is the approximate average composition of water in the basalt and intermediate aquifers.

Another possible source for water in the basalt and intermediate aquifers could be recharge during the Pleistocene age when Lake Lahontan last was present (about 4,000-7,000 years ago) Carbon-14 ages for water from some wells are old enough to support this origin, however, water in some wells is too young for this to be a realistic hypothesis Water in the basalt and intermediate aquifers could be the result of recharge several hundred years ago when Carson River water was isotopically lighter Several observations, including Pyramid Lake levels and cirque glacier reformation in the Sierra Nevada, suggest that the climate in the western United States was wetter and dominated by winter precipitation from 600 to 50 years ago (Davis, 1982, p 68) Presumably, precipitation during this time was isotopically lighter and recharge rates higher than during the present because of large unrestricted flows in the Carson River Carbon-14 ages for water in some wells suggest that the basalt and intermediate aquifers were recharged within the last several hundred years

Unlike water in the basalt and intermediate aquifers near Fallon, water in intermediate aquifers near the Upsal Hogback area has been affected by evaporation (fig 20) Prior to evaporation, the water probably had a stable-isotope composition similar to basalt aquifer water

Six samples from wells tapping intermediate aquifers analyzed for tritium had activities less than 16 pCi/L, except for samples from two wells in the western Carson Desert (table 5) These two wells yield water that probably was recently recharged from shallow aquifers Glancy (1986, p 32) reported tritium activities of less than 0 3 pCi/L for samples from three wells tapping the intermediate aquifers near Fallon The water from these three wells apparently was recharged more than 57 years ago

Most samples from wells tapping the basalt aquifer analyzed for tritium had activities greater than 10 pCi/L, indicating ages of less than 38 years Water from the basalt aquifer near the center of Fallon and at the Naval Air Station had tritium concentrations greater than 20 pCi/L (Glancy, 1986) For the basalt aquifer, this suggests recharge may be taking place near the center of Fallon and near Rattlesnake Hill, the only area where the basalt is exposed Surface water from irrigation canals is the most likely source of recharge in this area Recharge may be increased by pumping of wells completed in the basalt aquifer near Rattlesnake Hill The pumping causes lower hydraulic heads in the basalt, which results in greater ground-water flow into the basalt aquifer

WATER QUALITY AND AQUEOUS GEOCHEMISTRY

This section describes water quality of principal aquifers and the processes that produce the observed quality Other aquifers, the Carson River, and the West Fork Carson River, are discussed primarily because they affect water quality in principal aquifers For example, shallow and upland aquifers are described because they recharge principal aquifers

Nevada State drinking-water standards (table 6) provide an appropriate reference for evaluating the quality of ground water The standards, which apply to public water supplies, include primary maximum contaminant levels (MCL), secondary preferred standards (SPS), and secondary maximum contaminant levels (SMCL) MCL's were established because of human health concerns and specify enforceable maximum permissible levels of constituents in water delivered to the user of a public water-supply system SPS's relate to the aesthetic quality of water and are intended to be guidelines within the State, they are not enforceable The SPS's may be applied if levels are locally attainable—if not, SMCL's apply (Nevada Administrative Code, 1992, p 3) The primary and secondary maximum contaminant levels were adopted, with the addition of a SMCL of 2 mg/L (milligrams per liter) for fluoride, by the State of Nevada from the U S Environmental Protection Agency's National Drinking Water Regulations (Nevada Administrative Code, 1992) Although a drinking-water standard has not been established for radon, the U S Environmental Protection Agency (1991) has proposed a MCL of 300 pCi/L The proposed MCL for uranium is 20 μg/L and radium-226 and -228 each have a proposed standard of 20 pCi/L (U S Environmental Protection Agency, 1991)

Differences between MCL's and SMCL's can be illustrated by a comparison of arsenic, which has an MCL, with iron and manganese, which have SMCL's The standard for arsenic was established because of scientific evidence that human health can be adversely affected by concentrations greater than the standard In contrast, iron and manganese can stain clothes and plumbing fixtures when present in concentrations greater than the standards, but do not generally affect

Table 5 Carbon-13, carbon-14, and tritium in ground water of Carson Desert, Nevada

[Carbon-13 values relative to Peedee belemnite standard Abbreviations PMC, percent modern carbon, pCi/L, picocuries per liter, <, less than, --, no data, NA, not applicable]

Local number	Date	Carbon-13 (permil)	Carbon-14 (PMC)	Tritium (pCi/L)	Laboratory [1]
Shallow aquifers					
N17 E29 05BCBB1	03-08-89	-14 0	--	70	DRI
N18 E28 30BDBA1	03-07-89	-11 6	--	51	DRI
N19 E28 23DCDB1	03-09-89	-11 3	--	42	DRI
N19 E28 30ADBC1	02-23-89	-12 0	--	93	DRI
N19 E29 25AADA1	04-19-89	-14 1	--	39	USGS
N19 E30 23DBCD1	08-30-89	--	--	44	USGS
N19 E30 30BBBA1	04-19-89	-13 4	--	55	USGS
Intermediate aquifers					
N18 E29 02BADA1	04-28-89	-8 3	--	5	USGS
N18 E28 10CAAA1	01-27-89	-13 2	61	--	NA
N18 E28 23ADAA1	04-20-89	-8 5	41	--	NA
N18 E28 35CDBD1	04-18-89	-6 3	18	--	NA
N18 E29 05CCCB1	04-20-89	-10 7	62	--	NA
N18 E29 05DDAB1	03-08-89	-8 5	35	--	NA
N18 E29 18BAAD1	04-20-89	-8 8	40	--	NA
N18 E29 28DDCD1	04-21-89	-10 1	13	--	NA
N19 E27 13CCCB1	02-28-89	-11 0	90	67	DRI
N19 E27 19BCB 1	02-28-89	-12 2	85	90	DRI
N19 E28 24ADCC1	03-08-78	-11 0	62	< 3	USGS
N19 E28 24DABB1	03-08-78	-10 7	87	3	USGS
N19 E28 25BCDD1	03-07-89	-12 2	89	--	NA
N19 E29 07DAAD1	03-01-89	-11 4	69	--	NA
N19 E29 08DABC1	04-25-89	-9 9	18	< 3	USGS
N19 E29 17BABD1	05-31-89	-11 6	73	--	NA
N19 E29 29CACA1	02-22-89	-12 1	77	--	NA
Basalt aquifer					
N19 E28 36AABC1	10-06-78	-10 0	40	8 4	USGS
N19 E29 18DCBB1	03-02-89	-8 4	36	--	NA
N19 E29 29BACB1	03-01-89	-9 1	43	14	DRI
N19 E29 30CBAD1	01-25-89	-9 5	51	15	USGS
N19 E29 30CDBC1	08-10-78	-9 4	53	26	USGS
N19 E29 30CDBC2	01-25-89	-9 6	52	15	USGS
N19 E29 33CBBC1	01-26-89	-9 2	45	14	USGS
N19 E29 33CBBB2	02-22-78	-8 9	51	22	USGS
N20 E29 34BBAC1	06-01-89	-8 2	15	--	NA
N20 E29 34CCDC1	07-19-78	-6 9	30	6	USGS

[1] Laboratories performing tritium analysis DRI, Desert Research Institute, Reno, Nevada, USGS, U S Geological Survey, Arvada, Colorado

human health Sources and possible effects, either health related or aesthetic, for several constituents in ground water of the Carson River Basin are listed in table 7 These constituents consistently exceed established or proposed drinking-water standards in ground water of the basin

Some dissolved constituents reach concentrations that may impair use of the water, but do not have established or proposed drinking-water standards Four minor constituents in this category within the Carson River Basin are boron, lithium, molybdenum, and vanadium Concentration guidelines established for these elements in water for irrigation and livestock use are boron, 750 μg/L (U S Environmental Protection Agency, 1976), lithium, 100 μg/L (Hem, 1985, p 134 and 216), molybdenum, 10 μg/L (Committee on Water Quality Criteria, 1973, p 344), and vanadium, 100 μg/L (Committee on Water Quality Criteria, 1973, p 345)

Table 6 Nevada State drinking-water standards for public water systems

[Unit of measure milligrams per liter, except as noted, --, standard does not exist for indicated constituent or property]

Constituent or property	Primary maximum contaminant level (MCL)[1]	Secondary maximum contaminant level (SMCL)[2]	Secondary preferred standard (SPS)[3]
Inorganic constituents and properties			
Arsenic	0 05	--	--
Barium	1 0	--	--
Cadmium	01	--	--
Chloride	--	400	250
Chromium	05	--	--
Copper	--	--	1 0
Fluoride	4 0	2 0	--
Iron	--	6	3
Lead	05	--	--
Magnesium	--	150	125
Manganese	--	1	05
Mercury	002	--	--
Nitrate (as N)	10	--	--
Selenium	01	--	--
Silver	05	--	--
Sulfate	--	500	250
Dissolved solids	--	1,000	500
Zinc	--	--	5 0
pH (units)	--	--	6 5-8 5
Organic compounds			
Benzene	0 005	--	--
Carbon tetrachloride	005	--	--
Endrin	0002	--	--
Lindane	004	--	--
Methoxychlor	1	--	--
Trichloroethylene	005	--	--
Toxaphene	005	--	--
Trihalomethanes (total)	1	--	--
Vinyl chloride	002	--	--
1,2-Dichloroethane	005	--	--
1,1-Dichloroethylene	007	--	--
1,4-Dichlorobenzene	075	--	--
1,1,1-Trichloroethane	2	--	--
2,4-Dichlorophenoxyacetic acid (2,4-D)	1	--	--
2,4,5-Trichlorophenoxypropionic acid (2,4,5-T)	01	--	--
Radionuclides			
Adjusted gross alpha (excluding radium-226, radon, and uranium), in picocuries per liter[4]	15	--	--
Gross beta, in millirems per year	4	--	--
Radium-226 and -228 (combined), in picocuries per liter	5	--	--
Radium-226, in picocuries per liter[4]	20	--	--
Radium-228, in picocuries per liter[4]	20	--	--
Radon-222, in picocuries per liter[4]	300	--	--
Uranium' in milligrams per liter[4]	02	--	--

[1] Primary maximum contaminant level (MCL's) are health related and State and Federally mandated Best available technology as determined by U S Environmental Protection Agency must be utilized to achieve these levels (JeffreyA Fontaine, Nevada Bureau of Consumer Health Protection Services, oral commun , 1989) MCL's are adopted by the Nevada Administrative code (1992) from the National Drinking Water Regulations (U S Environmental Protection Agency, 1986a, b)

[2] Secondary maximum contaminant levels (SMCL's) are based on aesthetic qualities and are enforceable by the State of Nevada (Nevada Administrative Code, 1992) Best available technology is determined by the State of Nevada (Jeffrey A Fontaine, Nevada Bureau of Consumer Health Protection Services, oral commun , 1989) SMCL's, except that for magnesium, are adopted from National Drinking Water Regulations (U S Environmental Protection Agency, 1986c, p 587–590) SMCL's have not been established by the State of Nevada for copper, pH, and zinc

[3] Secondary preferred standards (SPS's) must be met unless water of that quality is not attainable, in which case existing SMCL's must be met (Nevada Administrative Code, 1992)

[4] Standard has been proposed but not adopted as of 1993 (U S Environmental Protection Agency, 1991)

Table 7 Source and significance of selected constituents in ground water of Carson River Basin, Nevada and California

[Constituents having maximum contaminant levels (MCL's) are in **bold** letters and listed first, constituents and properties having secondary maximum contaminant levels (SMCL's) are nonbold, constituents having proposed U S Environmental Protection Agency MCL's are in *italics* (Contaminant levels for individual constituents and properties are listed in table 6) Modified from Nowlin (1982, table 2) and Garcia (1989, table 1) Abbreviation mg/L, milligrams per liter]

Constituent or property	Major source	Significance
Arsenic	Common in basin-fill aquifers derived from weathering of intermediate and acidic volcanic rocks (Welch and others, 1988, p 334)	Two chemical forms trivalent (arsenite) and pentavalent (arsenate) The former is more toxic Epidemiologic studies have shown that arsenic can cause a variety of chronic and acute health problems, including skin cancer
Fluoride	Dissolved in small amounts from most rocks and soils Also common to most thermal water Concentrations commonly exceed 2 mg/L in ground water having low concentrations of calcium Added to many public water supplies to inhibit dental caries	Concentrations between 0 6 and 1 7 mg/L may have beneficial effects on structure and resistance to decay of children's teeth Concentrations in excess of 4 mg/L may cause mottling and pitting of teeth
Nitrate	Sources include fixation of atmospheric nitrogen by plants, leaching of decaying organic matter, fertilizers, or industrial, agricultural, or domestic wastes	Concentrations exceeding 10 mg/L may cause infant methemoglobinemia (blue-baby syndrome) High concentrations may indicate contamination from one or more human sources
Chloride	Dissolved in differing amounts from all rocks and soils High concentrations may be derived from marine and desert evaporite minerals such as halite May be derived from salts used for control of ice on streets and highways May be concentrated by evapotranspiration	May make water corrosive Imparts salty taste at concentrations as low as 100 mg/L Chloride ion is very stable in ground water and is often used as a tracer of movement of wastes in aquifers
Dissolved solids	Sum of all minerals dissolved from rocks and soils High dissolved-solids concentration generally is a result of dissolution of evaporite minerals (such as halite or gypsum) or concentration by evaporation	General indicator of overall chemical concentration of water Imparts unpleasant taste to water when concentrations exceed standards Additional effects on water uses depend on concentrations of individual constituents
Iron	Dissolved from iron minerals present in most rocks and soils Found in some industrial wastes, and can be corroded from pipes, well casings, pumps, and other equipment Also can be concentrated in wells and springs by certain bacteria	Oxidizes to a reddish-brown precipitate Stains utensils, enamelware, clothing, and plumbing fixtures May be objectionable for food and beverage processing because of taste and odor problems
Manganese	Dissolved from rocks, soils, and lake-bottom sediments Generally associated with iron	Oxidizes to form a dark brown or black precipitate Problems similar to those cause by iron
Sulfate	Dissolution of sulfate minerals such as gypsum, and sulfide minerals such as pyrite May be concentrated by evapotranspiration	Forms boiler scale in combination with calcium Causes bitter taste when combined in high concentrations with other ions, and may have laxative effects when first ingested in higher concentrations than those to which an individual is accustomed
Uranium	Dissolution of acidic plutonic rocks, sedimentary organic matter, and iron oxide	Chemical toxicity can cause kidney failure
Radon-222	Natural radionuclide in the uranium-decay chain	Rapidly volatilizes from ground water when it is exposed to atmosphere Inhalation may cause lung cancer

Water-Quality Data and Statistical Analysis

By **Alan H Welch**

The general chemical ionic composition, discharge or pH, and dissolved-solid concentrations of the Carson River are displayed in a five-field diagram in figure 21 One use of this diagram is to examine where data points tend to group in each of five individual triangular and rectangular areas Each chemical analysis is plotted as five points on the diagram and together they provide a broad visualization of the chemical composition of the water Relative proportions of major cations (calcium, magnesium, and sodium plus potassium) and major anions (carbonate plus bicarbonate, sulfate, and chloride) are shown on the left and upper triangles, respectively Dissolved-solids concentrations and discharge are plotted in the right and bottom rectangles, respectively Arrows in figure 21 show how cation and anion points for a single

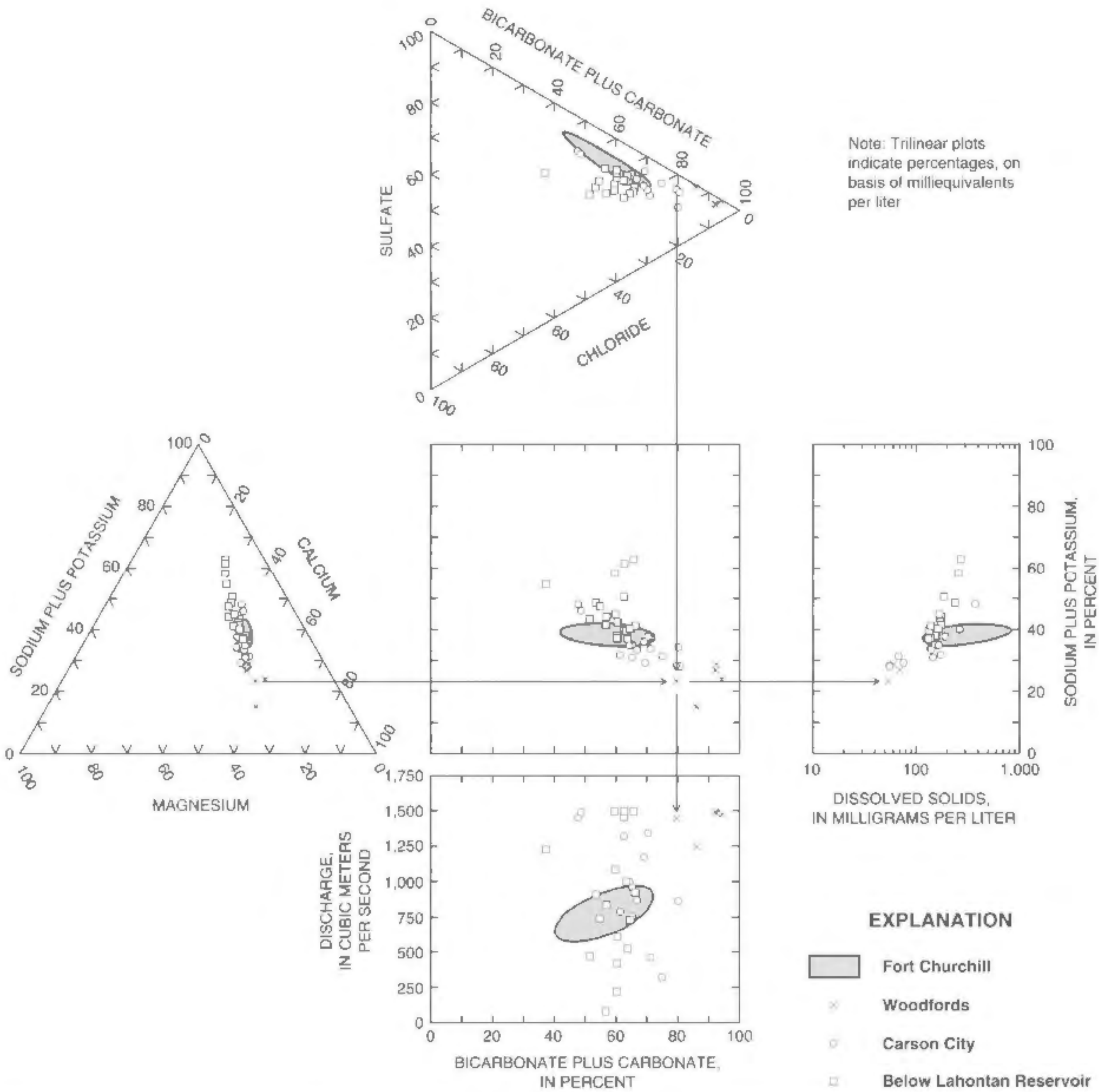


Figure 21. General chemical composition and discharge of Carson River and West Fork Carson River, Nevada and California. Envelope boundaries are derived by polar smoothing routines and encompass 50 percent of data. Arrows show projection scheme for individual chemical analysis.

analysis are projected from triangles to a central square and two rectangles. The central square functions primarily as a transitional area to connect the four outside plots. Where abundant data results in crowding, distinguishing the individual symbols is difficult. Where crowding is a problem, fields enclosing either 50 or 75 percent of the data are shown. These "envelopes" are defined by using polar-smoothing routines (Dennis Helsel, U.S. Geological Survey, written commun., 1992).

Boxplots, like those in figure 22, are used to display summary statistics regarding the distribution of reported concentrations for selected constituents. Statistical components are represented visually by features known as "boxes" and "whiskers," the box defines the spread of the middle 50 percent of the data (concentrations that lie between the 25th and 75th percentiles). A median value (the 50th percentile) is shown by a horizontal line within the box. Whiskers are vertical lines that extend from the ends of the box to the maximum and minimum values. Modified trilinear diagrams and boxplots are used to display a large number of data points in this report.

Bar graphs, such as figure 29, show frequencies with which data for selected constituents exceed primary and secondary drinking-water standards. Generally, constituents are shown only when more than 2 percent of the data exceed a standard.

Nonparametric statistics are included in this report because water quality and other environmental data commonly do not (or cannot be proved to) fit some common distribution. Additionally, extreme values are common, distorting the true central tendency of the data and making parametric statistics invalid. Nonparametric approaches use data ranks rather than actual values. Nonparametric approaches are only slightly less efficient than parametric tests when data are normally distributed and are more efficient when data are not normally distributed (Hollander and Wolfe, 1973, p. 1).

For a comparison of ranks, the Mann-Whitney test (Conover, 1980, p. 216) is used. The statistical difference between mean ranks of selected constituents is estimated by this method for (1) the different aquifers, (2) the upper, middle, and lower Carson River Basin, and (3) shallow ground water beneath agricultural and urban land.

A chi-square test for differences in probabilities (Conover, 1980, p. 145) is used to evaluate whether a significant proportion of samples from an aquifer have concentrations above a drinking-water standard. The test also is used to determine whether minor constituents are more commonly above laboratory reporting limits in one group of samples than in another.

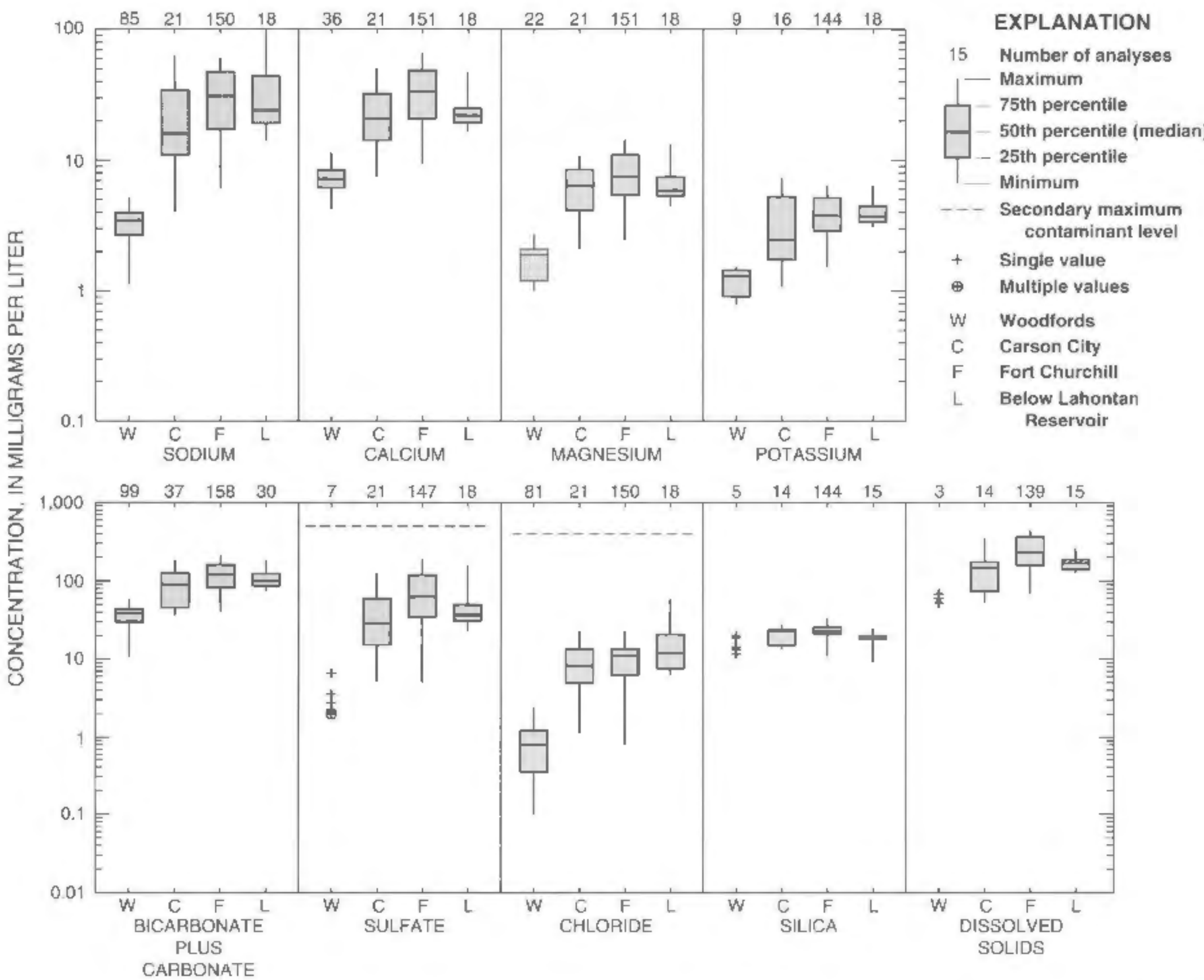


Figure 22. Summary statistics for major constituents at four Carson River and West Fork Carson River sites, Nevada and California.

The Mann-Whitney and chi-square tests yield a test statistic called a "p-value " For purposes of this report, the following terms describe significance for a range in the p-value highly significant, p less than or equal to 0 01, significant, p greater than 0 01 and less than or equal to 0 05, and not significant, p greater than 0 05 A confidence level is equal to 1 00 minus the p-value and is expressed as a percent For example, a p-value of 0 05 is equal to a 95-percent confidence level

A tendency for the concentration of one constituent to correspond to an increase or decrease in the concentration of another is evaluated using a statistic called "Spearman's rho" (Iman and Conover, 1983, p 126-129) For purposes of this report, the following terms describe the correlation between two constituents based on a range in absolute magnitude of Spearman's rho very strongly correlated, greater than or equal to 0 90, strongly correlated, 0 75 to less than 0 90, moderately correlated, 0 50 to less than 0 75, weakly correlated, 0 25 to less than 0 50, and not correlated, less than 0 25 For example, a Spearman's rho of 0 55 describes a moderate correlation Negative values indicate that one variable tends to decrease as a second variable increases A Spearman's rho is reported only for relations valid at the 95th-percent confidence level or greater (p-value less than or equal to 0 05)

Surface-Water Quality

***By* James M Thomas**

This section describes water quality of the main stem and West Fork of the Carson River The quality of this water is important because it is a source of recharge to the ground-water flow system Data collection sites with major-ion analyses used to describe water quality of the river are the West Fork at Woodfords near Carson City (where the river exits Carson Valley) above Lahontan Reservoir in Churchill Valley, and the Carson River and below Lahontan Reservoir (where it enters Carson Desert, fig 1) Comparisons of median concentrations (fig 22) and ranks (table 8) of major constituents show changes along the river Ranks also were compared after removing data for samples collected during periods of highest and lowest flow (the upper and lower 10-percent durations) Relations suggested by table 8, with the few exceptions noted in the table, are similar when data collected during periods of highest and lowest flow are excluded

Calcium and bicarbonate are the dominant ions in the dilute water of the West Fork Carson River at Woodfords (fig 21), where relative proportions of major ions generally are independent of flow Concentrations of the major constituents increase downstream from Woodfords (fig 22, table 8) The West and East Forks are the principal sources of irrigation water in Carson Valley Consequently, the river system is an important source of recharge to shallow aquifers Proportions of sodium, sulfate, and chloride are greater where the main stem passes Carson City (fig 21) Major constituents, except for chloride and silica, become even more concentrated as the river flows past Fort Churchill Sulfate contributes an increased proportion of the total anion concentration beyond Fort Churchill These changes in the water quality are

Table 8 Statistical comparison of ranked concentrations of major constituents in samples from the Carson River and West Fork Carson River, Nevada and California

[Constituents in **bold** and nonbold have, respectively, higher and lower ranked concentrations in more downstream part of basin, p-values determined by Mann-Whitney method (Conover, 1980, p 216) Symbol --, no constituent]

Location	Highly significant (p less than 0 01)	Significant (p less than or equal to 0 05 and greater than 0 01)	Not significant (p greater than 0 05)
Woodfords compared with Carson City	**Calcium, magnesium, sodium, potassium, chloride, sulfate, bicarbonate**	**Silica**[1], **dissolved solids**[2]	--
Carson City compared with Fort Churchill	**Calcium, sulfate, bicarbonate, dissolved solids**[3]	**Magnesium, sodium**[1], **potassium**[3]	Chloride, silica
Fort Churchill compared with below Lahontan Reservoir	Calcium, silica	Magnesium, **chloride**, sulfate[1], dissolved solids[1]	Sodium, potassium[1], bicarbonate

[1] Highly significant with data for highest and lowest flows (upper and lower 10-percent durations) removed
[2] Not significant with data for highest and lowest flows (upper and lower 10-percent durations) removed
[3] Significant with data for highest and lowest flows (upper and lower 10-percent durations) removed

most likely caused by return of irrigation water diverted from the river, evapotranspiration, and inflow of ground water

For most major constituents, the trend toward increasing concentration reverses at the site below Lahontan Reservoir Except chloride, all major constituents have median values lower than or similar to those for the river near Fort Churchill, and the spread of the middle 50 percent of the data is less (fig 22) This reversal probably is due to contributions of Truckee River water to Lahontan Reservoir by way of the Truckee Canal Much of the water passing Lahontan Dam is used for irrigation that recharges shallow aquifers in Carson Desert

Ground-Water Quality

***By* Alan H Welch**

This section includes discussions of the major inorganic constituents, minor inorganic constituents, radionuclides, and synthetic organic compounds in the ground water, and processes producing concentrations of the different constituents In this report, the major inorganic constituents are those that make up 98 percent or more of the total solute mass Minor inorganic constituents generally are present at concentrations less than 1 mg/L

Most data used to describe ground-water quality were collected as part of the NAWQA pilot program Other sources of data include inorganic chemical analyses of water from springs in the Carson Range (Feth and others, 1964), and inorganic chemical and tritium analyses of ground water in Eagle Valley (Szecsody and others, 1983) Data collected for monitoring ground-water quality in Carson Valley (Garcia, 1989, Thodal, 1992), for a study of irrigation drainage in Carson Desert (Rowe and others, 1991, Lico, 1992), and for a study of ground water beneath the southern Carson Desert (Glancy, 1986) also are used

A comprehensive description of regional ground-water quality can be made only if an adequate number and distribution, both areally and vertically, of chemical analyses are available General characterization of regional ground-water quality is usually constrained by the areal and vertical distribution of the sample sites Limited access for sampling, however, commonly results in an uneven distribution of sampled sites In the Carson River Basin, samples from only 39 upland aquifer sites were collected In contrast, analyses of water from shallow and principal aquifers are available for about 160 and 230 sites, respectively

A second constraint results from the water uses Wells tapping principal aquifers generally are used for drinking water or irrigation The selection of these wells may result in a biased sample population because wells drilled for public water supply that yield poor-quality water commonly are abandoned Consequently, the selection may result in a greater percentage of samples that meet the drinking-water standards than is truly representative of the entire aquifer system

Wells tapping principal aquifers also have variable open intervals or an annulus filled with gravel Different well construction means that some wells can produce water from an interval of 100 ft or more and others may produce water from an interval of 30 ft or less Most wells tapping principal aquifers are water-supply wells used primarily for domestic, municipal, and irrigation purposes Generally, these wells have open intervals within the most productive parts of the aquifer Consequently, the water quality of finer grained, less productive parts of principal aquifers, is probably not well represented The wells available for sampling tap only the upper part of the principal aquifer and generally are less than 400 ft deep, whereas the basin-fill deposits locally have thicknesses of 5,000 ft or more Because of these limitations, the data for principal aquifers are more representative of ground water used for public supply than of all ground water in the basin

Methods of Sample Collection and Data Compilation

***By* Alan H Welch**

Data collection required site selection, well pumping, sample collection, and measurement of unstable constituents Laboratory analyses were for a wide range of organic and inorganic constituents and isotopes Field and laboratory data, along with basic information on the wells, is included in a report by Whitney (1994) Surface-water samples were analyzed by U S Geological Survey laboratories Methods of sample collection are described by Garcia and others (1992)

About 30 wells tapping principal and upland aquifers in four areas were sampled as part of the NAWQA pilot project These areas are Carson Valley, Eagle Valley, the middle basin (Dayton and Churchill Valleys), and Carson Desert The wells are located throughout the valleys from which most of the ground water is withdrawn

Shallow wells were drilled for sampling the upper part of shallow aquifers using protocols described by Hardy and others (1989) Most shallow wells were drilled to depths less than 30 ft and completed within 20 ft beneath the shallow water table Because agriculture is a major land use, 30 wells were drilled in agricultural areas throughout the basin The wells were sited using a program written by Scott (1990) to ensure random distribution and geographic coverage of the basin Closely spaced, shallow wells also were drilled in three agricultural areas and in the urban part of Carson City

Most wells were drilled with a hollow-stem auger using a nationally consistent NAWQA quality-assurance plan (Mattraw and others, 1989) Cores of aquifer material were collected at the depth of screen placement for analysis of the solid phase Minerals forming shallow sediments were identified using a petrographic microscope and X-ray diffraction A total of 372 shallow soil samples was collected at the drilled sites and other sites throughout Carson Desert Chemical analyses of these samples are reported by Tidball and others (1991)

Ground-water samples were collected using methods and protocols described by Hardy and others (1989) The procedures specify that wells be pumped with a positive-displacement pump until several monitored properties (pH, specific conductance, temperature, and dissolved oxygen) are constant before the sample is collected Most constituents were analyzed by the U S Geological Survey National Water Quality Laboratory (NWQL) in Arvada, Colo Radionuclides (except radon-222) and stable isotopes of carbon and sulfur were analyzed by a contractor to the NWQL, and stable isotopes of water were analyzed by the U S Geological Survey laboratory in Menlo Park, Calif Tritium was analyzed at two different laboratories (Desert Research Institute laboratory in Reno, Nev , and the University of Miami through a contract to the U S Geological Survey) Methods of analysis are described by Fishman and Friedman (1985), Thatcher and others (1977), and Wershaw and others (1987)

Compiled water-quality data for the Carson River Basin include multiple analyses of some wells and springs To avoid bias toward repeatedly sampled sites, only the most recent analyses are used in the spatial description of ground-water quality The most recent analyses (most of which are for samples collected since 1985) are used because analytical precision and accuracy generally are improved in comparison to older analyses

Major-ion analyses were eliminated from the data set if the absolute value of the difference between the milliequivalents of the cations and anions divided by the sum of the two is greater than 10 percent

Different aspects of ground-water quality in the area are displayed on graphic plots Depending on the hydrographic area, the illustrations include (1) maps that show all sampling sites and highlight those where concentrations of selected constituents exceed the Nevada State drinking-water standards, (2) a diagram showing the general chemical composition of the water, (3) a bar graph showing percentages of samples that exceed selected Nevada State drinking-water standards, and (4) boxplots showing the statistical distribution of concentrations or activities

Concentrations of Major Constituents

***By* Michael S. Lico**

This section describes the concentrations of major constituents in ground water of the Carson River Basin Comparisons between median concentrations of major constituents in individual valleys and aquifer systems are given The quality of ground water also is compared to current Nevada State drinking water standards

The chemical composition of ground water in principal aquifers beneath Carson and Eagle Valleys is dominated by calcium, sodium plus potassium, and bicarbonate (fig 23*A*) Dissolved-solids concentrations generally are less than 300 mg/L and pH values generally are between 7 and 8 Chloride concentrations typically are less than 10 mg/L, corresponding to the relatively dilute composition of the water (fig 24*A*)

All major constituents except potassium have lower median and ranked concentrations in water from upland aquifers than from principal aquifers (table 9, fig 24*A*) Lower concentrations are consistent with the upland aquifers as a source of recharge to principal aquifers Additionally, many samples were collected in areas underlain by granitic rocks, which generally yield water with lower dissolved-solids concentrations

Ground water in shallow aquifers beneath Carson and Eagle Valleys has a wider range of dissolved solids and ionic compositions than water in principal aquifers Most water in shallow aquifers is dominated by sodium plus potassium, calcium, and bicarbonate (fig 23*B*) Dissolved-solids concentrations generally range from 300 to 600 mg/L and pH values generally are near 7 Much of the shallow ground water in Carson Valley is recharged by irrigation Carson River is the

Table 9. Statistical comparison of ranked concentrations of major constituents in water from principal aquifers and water from upland and shallow aquifers of Carson River Basin, Nevada and California

[Constituents in **bold** and nonbold have, respectively, higher and lower ranked concentrations in principal aquifers; p-values determined by Mann-Whitney method (Conover, 1980, p. 216). Symbol: --, no constituent]

Location	Aquifer system	Highly significant (p less than 0.01)	Significant (p greater than 0.01 and less than or equal to 0.05)	Not significant (p greater than 0.05)
Carson and Eagle Valleys	Upland	**Sodium, chloride, sulfate, silica, dissolved solids**	**Bicarbonate, calcium, magnesium**	Potassium
	Shallow	Calcium, magnesium, sodium, chloride, sulfate, bicarbonate, dissolved solids	Potassium, silica	--
Carson Desert	Shallow	Calcium, magnesium, sulfate	Bicarbonate	Sodium, potassium, silica, chloride, dissolved solids

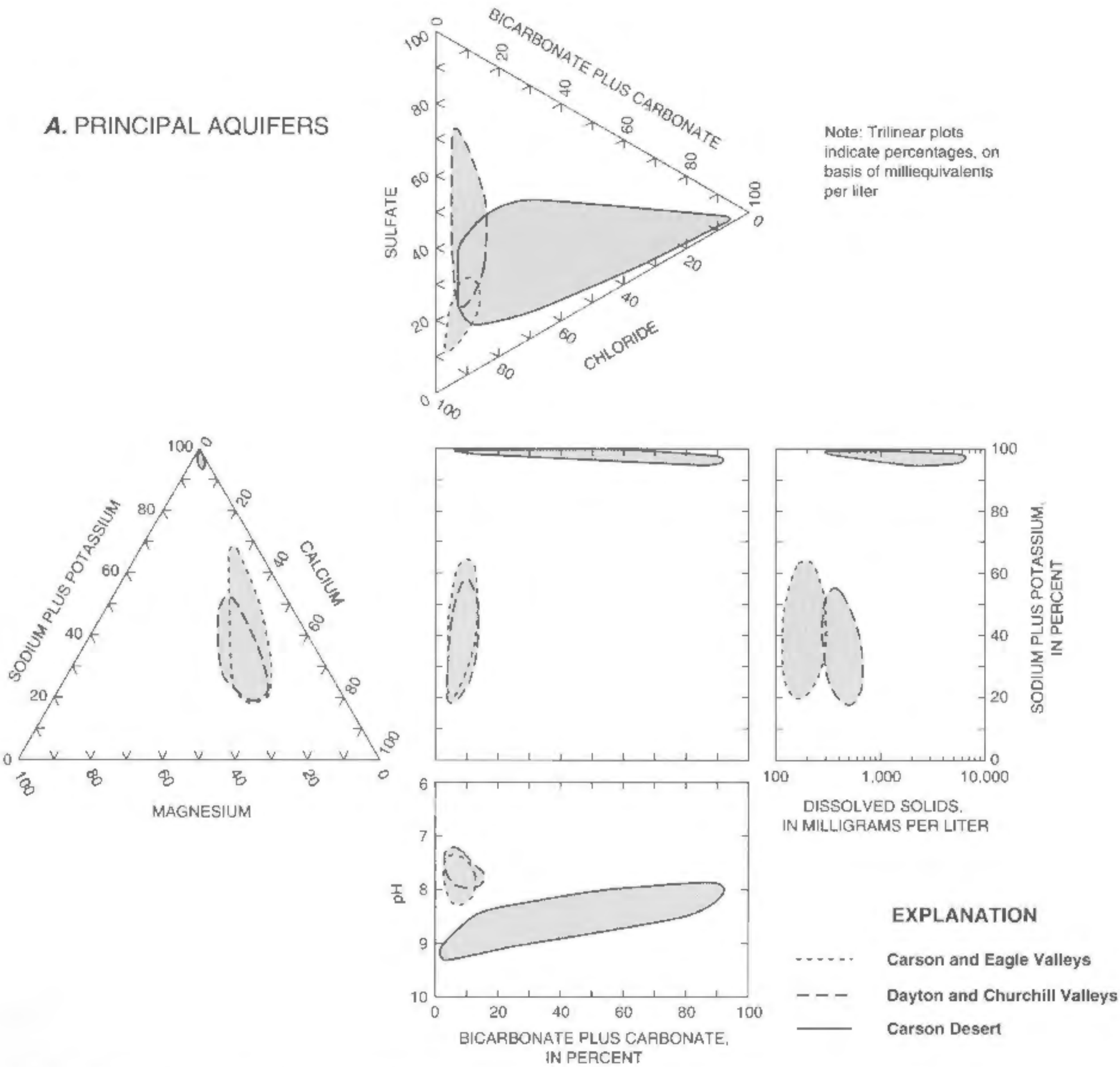
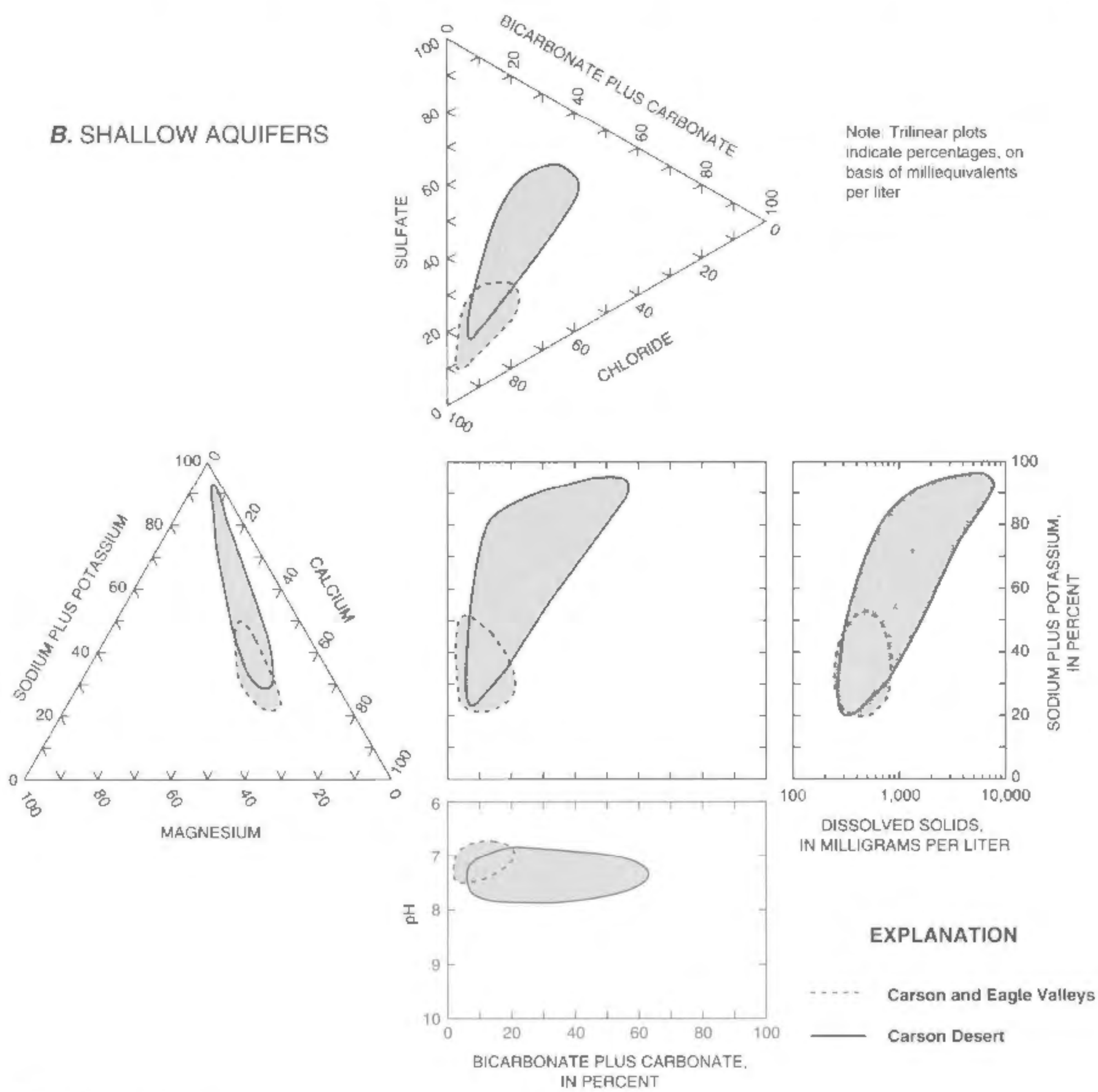


Figure 23. General chemical composition of ground water in Carson River Basin, Nevada and California. Envelope boundaries are derived by polar smoothing routines and encompass 50 percent of data for each area. *A*, Water from principal aquifers; and *B*, Water from shallow aquifers.

primary source of irrigation water. The generally higher concentrations of major constituents in water in shallow aquifers than in water in principal aquifers (table 9, fig. 24*A*) are consistent with concentrations in much of the shallow water discharging to the river. Except for areas near major pumping of ground water, such as near Gardnerville and along the Carson River east of Carson City, the river probably is not a major source of recharge to principal aquifers.

In Dayton and Churchill Valleys, ground-water quality in principal aquifers is dominated by the cations sodium plus potassium and calcium; bicarbonate and sulfate are the dominant anions (fig. 23*A*). Dissolved-solids concentrations in water from principal aquifers of Dayton and Churchill Valleys generally are greater than in water from principal aquifers of Carson and Eagle Valleys. Greater dissolved-solids concentrations result from higher concentrations of most major constituents (table 10; fig. 25), most notably from sulfate. Median concentrations of sulfate in principal aquifers increase from less than 20 mg/L in the upper Carson River Basin to more than 80 mg/L in the middle and lower basin (fig. 25).

Water from principal aquifers of Carson Desert generally is dominated by sodium plus potassium, and bicarbonate or chloride ions (fig. 23*A*). As dissolved-solids concentrations increase, chloride becomes more dominant. Sulfate also is a major part of the total anion



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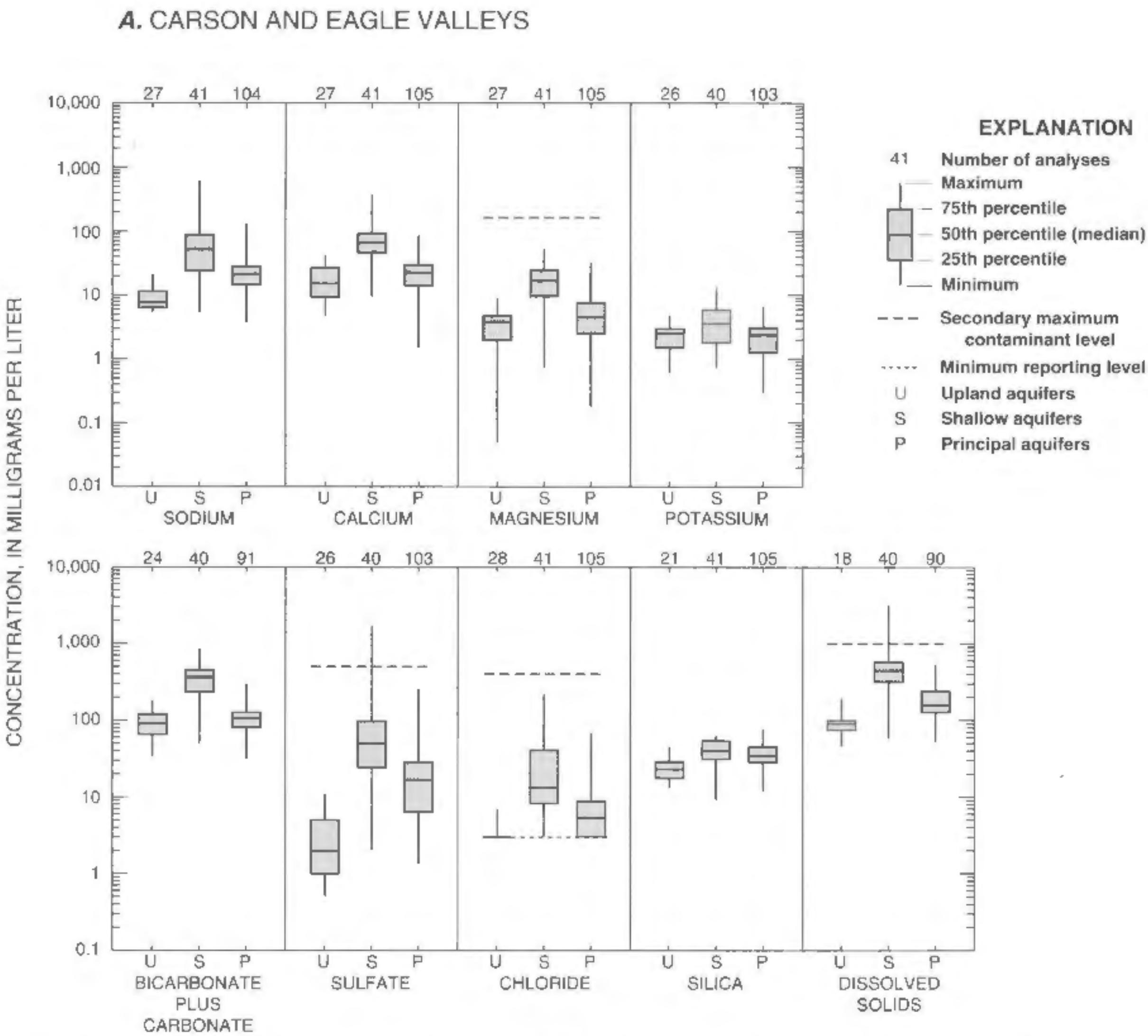


Figure 24. Summary statistics for major constituents in the different aquifer systems of Carson River Basin, Nevada and California. *A*, Carson and Eagle Valleys; and *B*, Carson Desert.

composition in some ground water. Dissolved-solids concentrations in water from principal aquifers in Carson Desert generally are greater than in ground-water from other parts of the Carson River Basin (fig. 25). The Carson Desert ground water also is more alkaline, with pH values generally ranging from 8 to 9. Concentrations of sodium, potassium, chloride, and bicarbonate are all distinctly higher in ground water from Carson Desert than in ground water from the upper and middle basin (table 10, fig. 25). The median chloride concentration for Carson Desert (about 260 mg/L) is more than 10 times greater than the median for the middle Carson River Basin (about 15 mg/L). Median concentrations in the basin (lower compared to the middle basin) are greater by factors of about 8 and 1.7 for sodium and bicarbonate, respectively (fig. 25). In contrast, medians and ranked concentrations of magnesium and calcium are lower in Carson Desert than in the upper and middle basin. As discussed in the following section, these lower concentrations are probably caused by exchange of calcium and magnesium in the water for sodium on clay-mineral surfaces.

Shallow aquifers beneath Carson Desert contain water with a wide range in composition and dissolved-solids concentration (fig. 23*B*). Much of the water is dominated by bicarbonate, sodium plus potassium, and calcium (or just sodium). In general, increases of dissolved-solids concentrations correspond to increasing dominance of sodium and chloride (fig. 23*B*). Water with the higher dissolved-solids concentrations

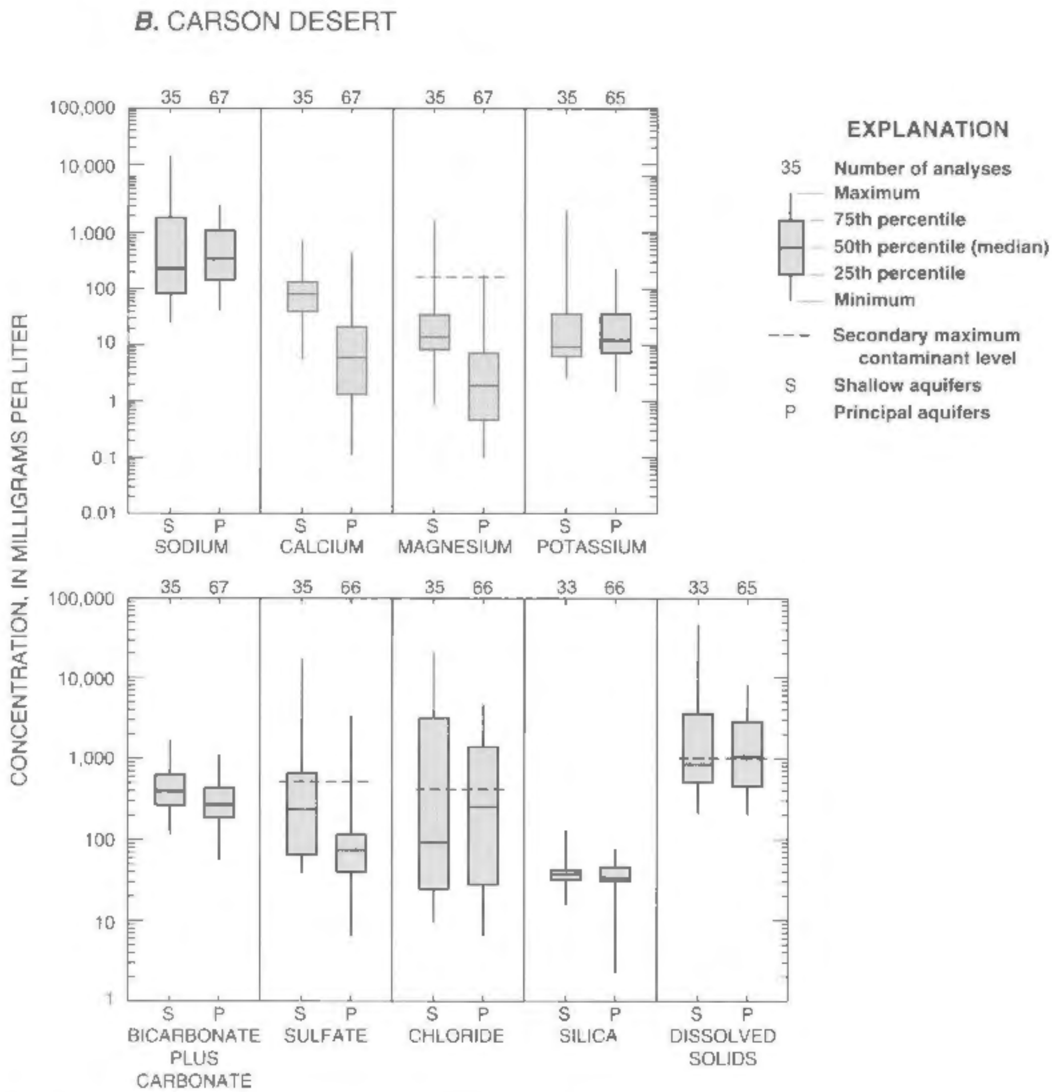


Figure 24. Continued.

is found in areas of intense evapotranspiration from the shallow subsurface. Most samples had dissolved-solids concentrations less than 10,000 mg/L, but the maximum measured concentration was 41,000 mg/L.

Secondary maximum contaminant levels (SMCL's) have been established for sulfate, chloride, magnesium, and dissolved solids (table 6). Where the concentration of one of these constituents exceeds the SMCL, the dissolved-solids concentration also exceeds the SMCL. Most samples with high dissolved-solids concentrations are from topographically low areas in the Carson Desert—Stillwater Marsh, Carson Sink, and Carson Lake areas (fig. 26). Intense evapotranspiration accompanied by dissolution of salts, such as halite and gypsum, are the most likely causes of the high dissolved-solids concentrations. Ground water with high dissolved-solids concentrations in the middle basin generally also has high sulfate concentrations. Water with high dissolved-solids and sulfate concentrations is in principal aquifers of Dayton Valley. Water with high dissolved-solids content in the upper Carson River Basin is limited to shallow aquifers—two sites are in the Carson City urban part of Eagle Valley and one site is in northern Carson Valley.

Processes Producing Concentrations of Major Constituents

***By* Michael S. Lico**

The purpose of this section is to describe the physical and chemical processes resulting in observed concentrations of major constituents in ground water of

Table 10. Statistical comparison of ranked concentrations of major constituents in ground water from upper, middle, and lower Carson River Basin, Nevada and California

[Constituents in **bold** and nonbold have, respectively, higher and lower ranked concentrations in more downstream part of basin; p-values determined by Mann-Whitney method (Conover, 1980, p. 216). Symbol: --, no constituent]

Area	Highly significant (p less than 0.01)	Significant (p greater than 0.01 and less than or equal to 0.05)	Not significant (p greater than 0.05)
	Principal aquifers		
Carson and Eagle Valleys compared with Dayton and Churchill Valleys	**Calcium, magnesium, sodium, potassium, chloride, sulfate, bicarbonate, silica, dissolved solids**	--	--
Dayton and Churchill Valleys compared with Carson Desert	Calcium, magnesium, **sodium, potassium, chloride, bicarbonate**, silica, **dissolved solids**	Sulfate	--
Carson and Eagle Valleys compared with Carson Desert	Calcium, magnesium, **sodium, potassium, chloride, sulfate, bicarbonate, dissolved solids**	--	Silica
	Shallow aquifers		
Carson and Eagle Valleys compared with Carson Desert	**Sodium, potassium, chloride, sulfate, dissolved solids**	Bicarbonate	Calcium, silica, maguesium

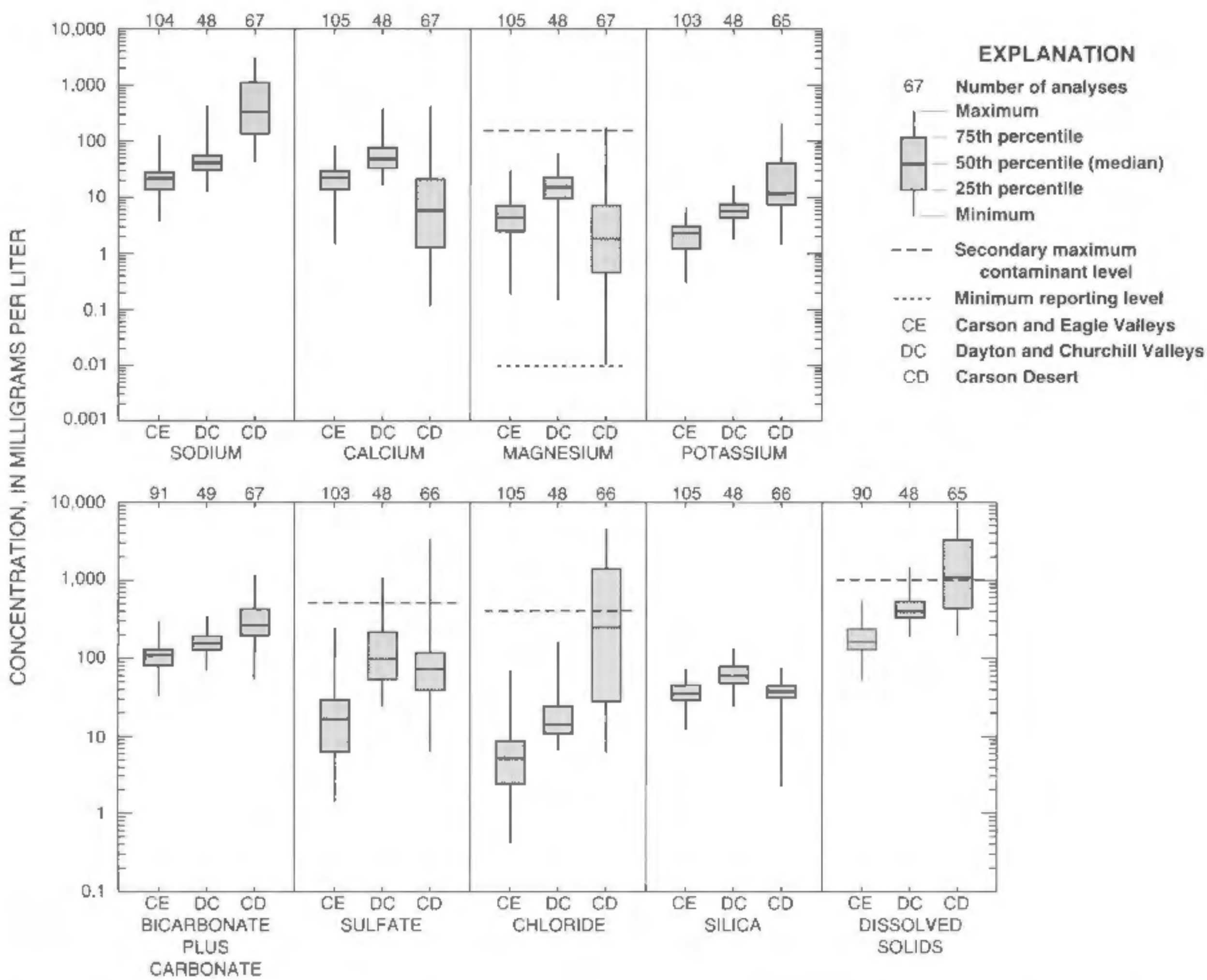


Figure 25. Summary statistics for major constituents in principal aquifers of Carson River Basin, Nevada and California.

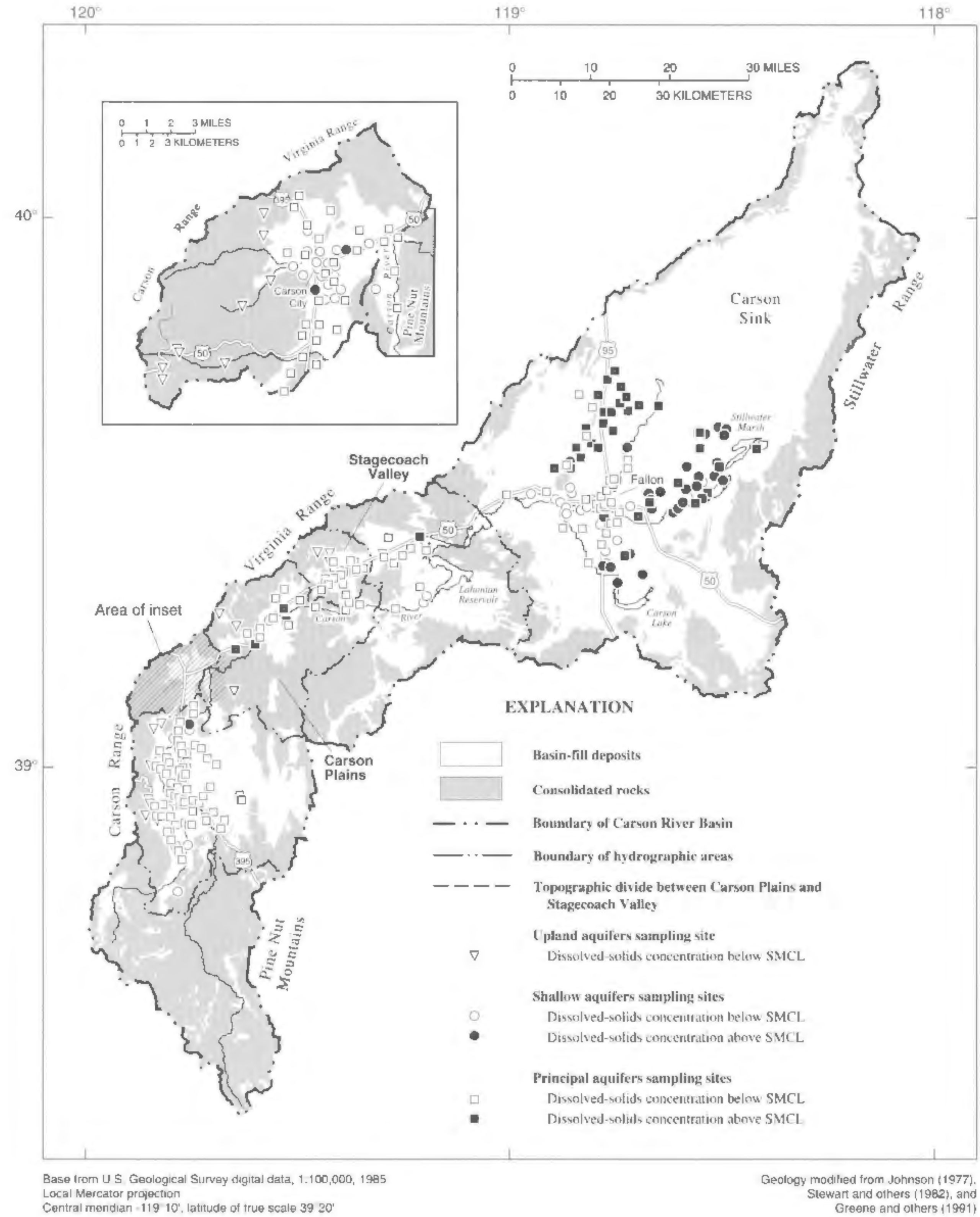


Figure 26. Ground-water sampling sites in Carson River Basin, Nevada and California, where concentrations of dissolved solids exceed Nevada State secondary maximum contaminant levels (1,000 milligrams per liter). SMCL, secondary maximum contaminant level.

the Carson River Basin Some introductory explanations of processes that commonly control ground-water quality of inorganic constituents are included These processes can be important controls on major and minor inorganic constituents and radionuclides A discussion of the use of thermodynamic and isotope data in determining processes also is included

Concentrations of inorganic constituents in ground water are controlled by a variety of geochemical processes including reaction kinetics, mineral solubility, adsorption, and ion exchange Application of laboratory-derived reaction rates requires information unavailable for the Carson River Basin and, therefore, is considered only generally Radioactive isotopes produced by radioactive decay, such as radon, are controlled by the concentration of the parent and half-lives of intermediate progeny products in the decay chain Additionally, some constituents are present in only small amounts within aquifer materials

Mineral solubility as a control on concentrations generally is evaluated using computer programs that calculate the state of saturation with respect to minerals and other solid phases The program WATEQ4 (Ball and others, 1987) was used to estimate a measure of saturation termed a "saturation index," which is the log of the activity product divided by the equilibrium constant For example, a saturation index for the calcium sulfate mineral gypsum is

$$\text{saturation index} = \text{Log}\ \{[Ca^{2+}]\ [SO_4^{2-}]\ /\ (\text{equilibrium constant for gypsum})\},$$

where values in square brackets are chemical activities of calcium and sulfate (Hem, 1985, p 19) Positive values for the saturation index indicate oversaturation with respect to a solid phase, whereas negative values indicate undersaturation For purposes of discussion, saturation index values between -0 5 and 0 5 are considered to indicate equilibrium Greater and lesser values indicate oversaturation and undersaturation, respectively One limitation of the WATEQ4 program is that chemical-activity coefficients for dissolved species are calculated using the extended Debye-Huckel equation, which becomes increasingly inaccurate for ionic strengths greater than about 0 1 (Stumm and Morgan, 1970, p 83) Some ground water in Carson Desert has ionic strengths greater than 0 1, accordingly, chemical activities and saturation indexes are reported only for ground water with ionic strengths less than 0 5

Stable isotopes of dissolved inorganic sulfur and carbon can aid in understanding reactions in ground water Differences in stable-isotope compositions can be caused by (1) differences in the isotope composition of recharge water, (2) variations in the isotopic composition of minerals dissolved by ground water, (3) the amount of a mineral that is dissolved, (4) mineral precipitation, (5) concentration by evapotranspiration, or (6) microbial processes, such as sulfate reduction

The stable-isotope composition of sulfur (as dissolved sulfate) is highly variable in ground water throughout the Carson River Basin (fig 27) In the upper Carson River Basin, sulfate has at least three isotopically distinct sources (Welch, 1994) (1) Lighter (more negative) sulfur is derived from dissolution of sulfide minerals in granitic rocks of the Sierra Nevada Therefore ground water in upland areas generally has a lighter sulfate-isotope composition (2) To the east (downgradient) of metavolcanic rocks in the Carson Range, the sulfate in ground water is isotopically heavier Apparently, these rocks have a source of heavier sulfur than granitic rocks Ground water with the heaviest sulfur-isotope composition in the Carson River Basin is in northeastern Eagle Valley (3) Dissolved sulfate also is derived from Triassic and Jurassic evaporite deposits containing gypsum and gypsum-rich detritus in the basin-fill sediment All common sulfur-bearing minerals are undersaturated in ground water of Carson and Eagle Valleys This suggests precipitation of sulfur-containing minerals does not modify the stable-isotope composition of dissolved sulfur

In Dayton and Churchill Valleys, sulfate concentrations in ground water generally are higher than in Carson and Eagle Valleys (fig 25) The stable-isotope composition of dissolved sulfate is similar to that of ground water from Carson and Eagle Valleys (fig 27, Thomas and Lawrence, 1994) Sources of dissolved sulfate include dissolution of gypsum deposits, in volcanic rocks and granite, some sulfate may be microbially reduced, as indicated by the lighter sulfur-isotope composition in one water sample than in rock sources Evidence of precipitation of sulfur-bearing minerals in the middle Carson River Basin has not been observed

The sulfur-isotope composition is highly variable in ground water of Carson Desert (fig 27) Sources of dissolved sulfate in ground water include dissolution of pyrite from volcanic and granitic rocks and dissolution of gypsum from desert sediments Lighter sulfur-isotope compositions are similar to those for granitic rocks of the Sierra Nevada (fig 27), indicating the granitic rocks and their sedimentary derivatives are sources of dissolved sulfate Ground water in intermediate aquifers commonly has lower sulfate concentrations and heavier sulfur-isotope compositions than

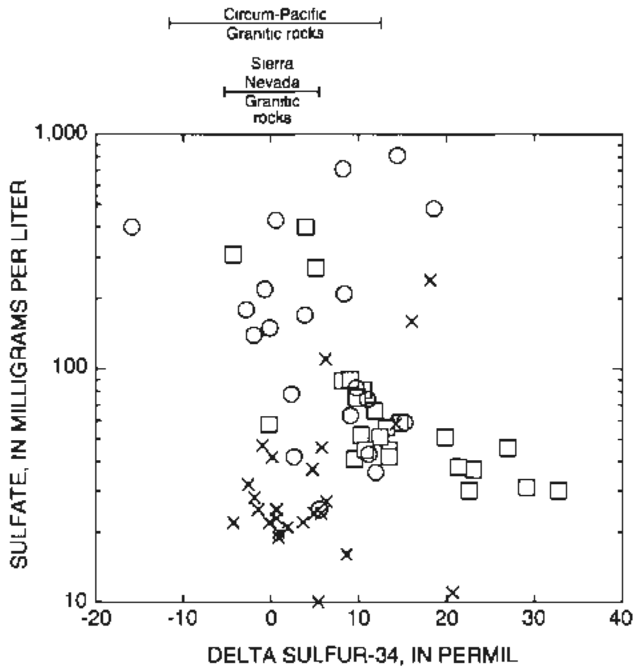


Figure 27. Relation between stable isotopes of sulfur and sulfate concentrations in ground water of Carson River Basin, Nevada and California

ground water in shallow aquifers If sulfate in both aquifers is from the same source, microbial reduction of sulfate (Krouse, 1980, p 458-461) probably is the cause of heavier sulfate and lower concentrations in intermediate aquifers Precipitation of sulfur-bearing minerals also can alter the sulfur-isotope composition However, precipitation of sulfur-bearing minerals from ground water in the Carson River Basin has not been documented, except in shallow aquifers near Stillwater Wildlife Management Area (Lico, 1992)

The stable-isotope composition of dissolved inorganic carbon is variable in ground water of the Carson River Basin (fig 28) Concentrations of dissolved inorganic carbon generally increase eastward in the basin Sources of carbon in ground water include the atmosphere and the soil zone as carbon dioxide, calcite, and organic carbon Soil-zone carbon dioxide dissolves in ground water, resulting in a weak carbonic acid solution that dissolves calcite in granitic rock or basin-fill sediment in Carson and Eagle Valleys Oxidation of organic carbon probably adds a small amount of carbon to the dissolved inorganic carbon in ground water

In Dayton and Churchill Valleys, dissolved-inorganic-carbon concentrations and carbon stable-isotope compositions are primarily the result of dissolution of soil-zone carbon dioxide in ground water in recharge areas Subsequent precipitation of calcite preferentially removes heavier carbon from the ground water, leaving a lighter dissolved-inorganic-carbon composition Oxidation of organic matter with an isotope composition similar to soil-zone carbon dioxide may contribute a small amount of carbon to the dissolved inorganic carbon in ground water

In Carson Desert, concentrations of dissolved inorganic carbon in ground water are much greater than concentrations in ground water in the middle and upper Carson River Basin Evapotranspiration has a major affect by concentrating the dissolved inorganic carbon, especially in shallow aquifers near Carson Lake and Stillwater Wildlife Management Area Ground water with the highest dissolved-inorganic-carbon concentrations also has the heaviest carbon-isotope composition, indicating the most likely source of heavy carbon is calcite present in the basin-fill sediment Calcite in shallow aquifers (8 samples) has a carbon-isotope composition between -6 8 and 0 9 permil, which is heavy enough to cause the observed values, organic carbon, with a range of -25 2 to -22 9 permil in 14 samples, has a carbon-isotope composition too light to cause the observed values

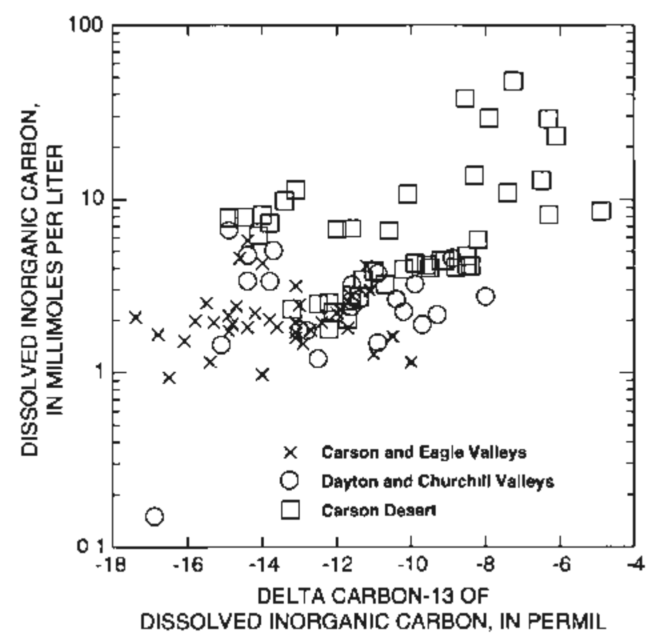


Figure 28 Relation between stable isotopes of carbon and inorganic-carbon concentrations in ground water of Carson River Basin, Nevada and California

Most ground water in the Carson River Basin is at equilibrium with calcite and amorphous silica (fig 29) Thus, solubility of calcite limits concentrations of calcium and dissolved inorganic carbon Similarly, solubility of amorphous silica limits concentrations of dissolved silica

Interpretation of activity diagrams, such as those shown in figures 30*A-G*, indicate that clay minerals are an important control on the cation composition of ground water in the basin Chemical activity ratios for ground water generally plot along slopes consistent with cation exchange reactions Specifically, if concentrations of a divalent cation (such as calcium) and a monovalent cation (such as sodium) are controlled by exchange, then a slope of 2 will result (figs 30*A* and *C*) Similarly, exchange of two cations with the same valence will result in a slope of 1 (fig 30*B*)

Most ground-water data for the Carson River Basin lie along trend lines consistent with cation exchange Some data, mostly for samples from the shallow aquifers in Carson Desert, do not indicate that exchange controls the relation between sodium and calcium A different process may be removing calcium from solution as concentrations of sodium plus calcium increase A likely explanation for the decrease in calcium is precipitation of calcite The presence of secondary calcite (overgrowth) in sediment from Carson Desert (fig 5) and Stillwater Wildlife Management Area (Lico, 1992) is consistent with the precipitation of calcite

Relations between activities of cations and silica are shown in figures 30*D-G* Fields in these plots indicate relations between ground-water compositions and mineral stability The clay minerals, kaolinite and beidellite, may be stable in aquifers of the Carson River Basin Ground water in Carson and Eagle Valleys typically is in the stability field for kaolinite In the middle and lower Carson River Basin, beidellite is more commonly the stable clay mineral For some ground water, mostly from Carson Desert, chlorite may be a stable mineral Also shown in figures 30*D-G* is a line representing saturation of amorphous silica Few samples have silica concentrations greater than saturation, probably because amorphous silica is the major control on dissolved silica concentrations

Three general models were evaluated to determine reaction paths for ground water in western Carson and Eagle Valleys "silicate," "closed system," and "open system" models (Welch, 1994, p 42-57) Each model started with the average chemical composition of atmospheric precipitation and ended with the composition of water samples from principal aquifers The "silicate" model did not contain calcite as a mineral phase and did not explain observed water chemistry in principal aquifers The "open" and "closed" system models have broadly similar results In both models, plagioclase feldspar is the major source of dissolved solids, calcite, carbon dioxide, pyrite, sodium chloride, and silica contribute a small amount of the dissolved solids content Kaolinite and sodium beidellite are major products formed by reactions within aquifers Cation-exchange processes also modify cation ratios in ground water

In Dayton Valley, water chemistry can result from dissolution of plagioclase feldspar, sodium chloride, gypsum, and small amounts of potassium feldspar, biotite, and chlorite (Thomas and Lawrence, 1994, p 24-32) Products formed by reactions in aquifers are calcite, kaolinite, sodium beidellite, and carbon dioxide gas Exchange processes caused the observed cation concentrations in ground water Water chemistry in Churchill and Stagecoach Valleys can be explained using a model similar to that for Dayton Valley, except that chlorite and potassium feldspar are not involved

Three reaction paths were modeled for aquifer systems in Carson Desert (Lico and Seiler, 1994, p 40-55) These reactions cause changes in water chemistry as water flows from shallow aquifers to the intermediate aquifers, from shallow aquifers to the basalt aquifer, and from intermediate aquifers to the basalt aquifer In general, dissolution of plagioclase feldspar, formation of sodium beidellite, cation exchange, and evapotranspiration are major processes controlling the composition of ground water Most models constructed for these reaction paths included solution and precipitation of small amounts of calcite and silica along with minor amounts of other minerals

Concentrations of Minor Constituents
***By* Stephen J Lawrence**

Minor inorganic constituents (arsenic, boron, fluoride, iron, lithium, manganese, molybdenum, nitrate, and vanadium) reach concentrations that can affect use of ground water in the Carson River Basin, particularly in Carson Desert Large differences in concentration are found in water from the different aquifers in the three parts of the basin Some differences are shown by comparing shallow ground water beneath agricultural and urban settings Concentrations of minor

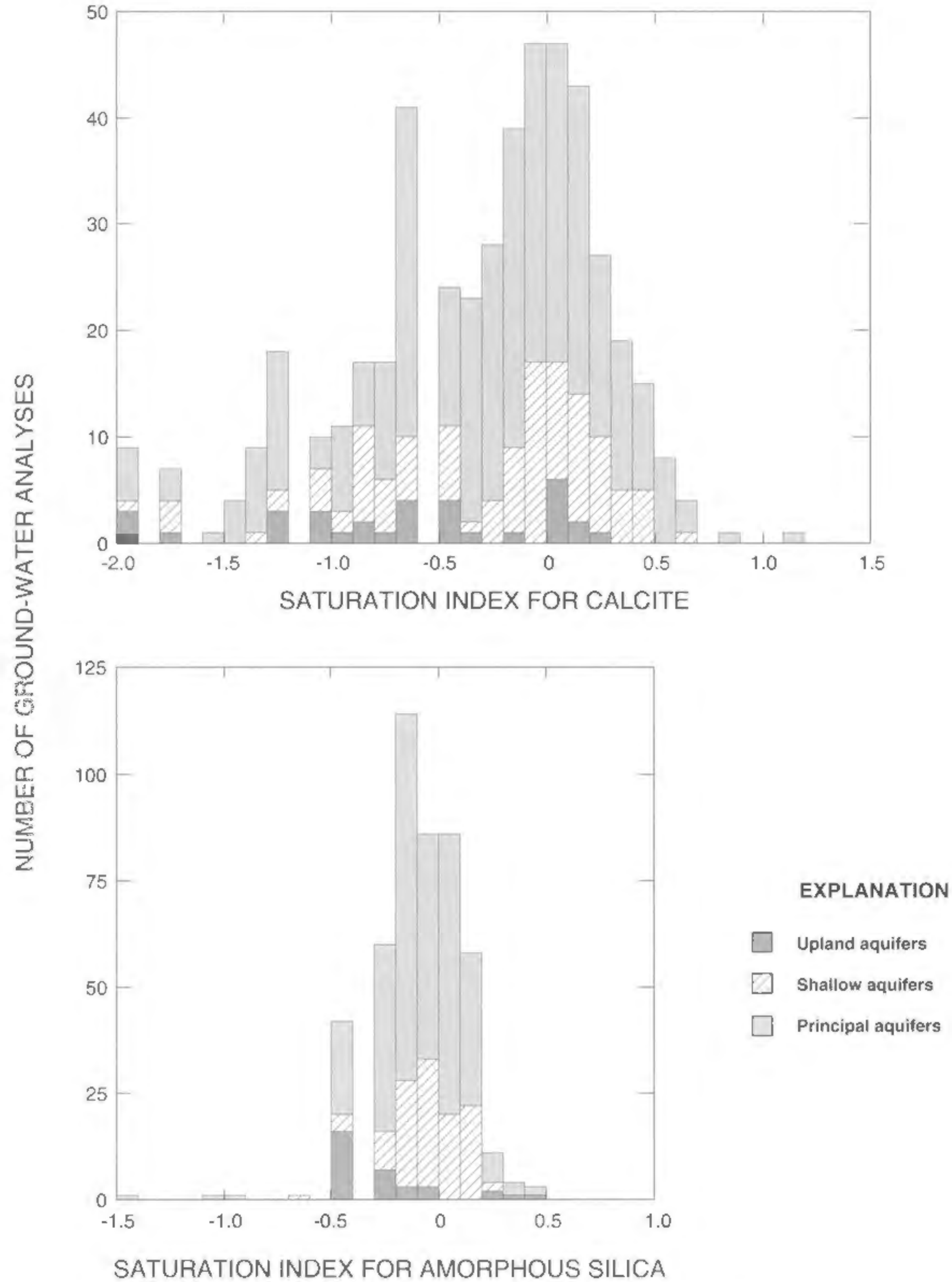


Figure 29. Saturation indexes for calcite and amorphous silica in ground water of Carson River Basin, Nevada and California.

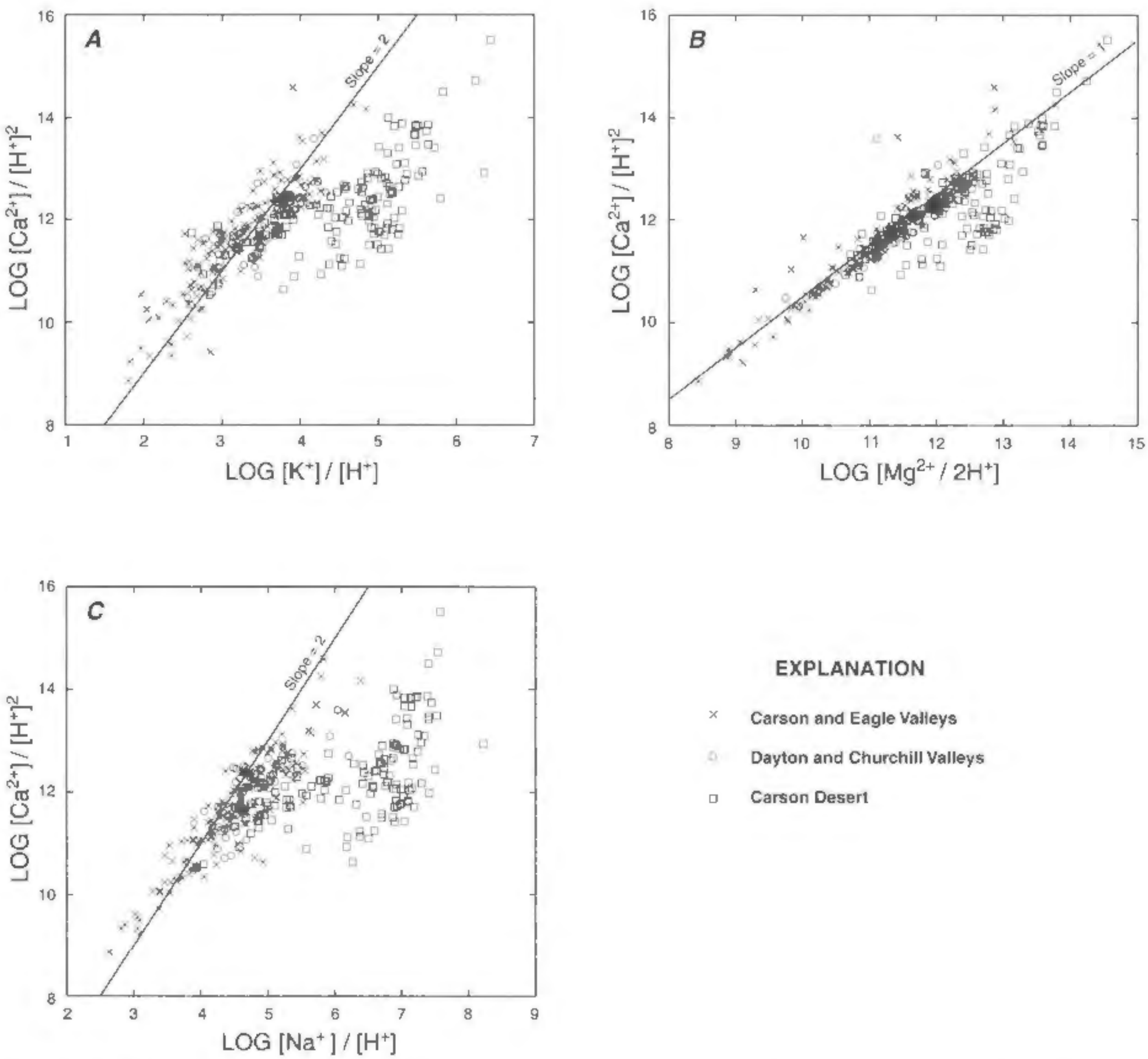


Figure 30. Relation between activities of selected major constituents in ground water of Carson River Basin, Nevada and California. *A*, Calcium and potassium; *B*, Calcium and magnesium; *C*, Calcium and sodium; *D*, Calcium and silica; *E*, Potassium and silica; *F*, Magnesium and silica; and *G*, Sodium and silica.

constituents can differ greatly over small vertical and horizontal distances, particularly in shallow aquifers of Carson Desert. Nitrate, although not always considered a minor constituent, is included in this section because its concentrations generally are less than 1 mg/L, expressed as nitrogen.

Except for manganese in shallow aquifers, ground water of Carson and Eagle Valleys has low concentrations of minor constituents compared to drinking-water standards and the guidelines previously discussed (fig. 31). Water in principal aquifers has significantly higher ranked concentrations of boron and fluoride compared to water in the upland aquifers (table 11). Although ranked iron concentrations are significantly higher in water from the upland aquifers than from principal aquifers, the median concentrations are similar (11 and 7 µg/L, respectively). Among the minor constituents with significantly higher ranked concentrations in water from shallow aquifers than from principal aquifers, only manganese concentrations exceed the SMCL in more than 25 percent of the samples (fig. 31*A*).

Ground water beneath agricultural land in Carson Valley and the urban part of Carson City has been analyzed for chloride and minor constituents. Chloride is included in this comparison because of possible

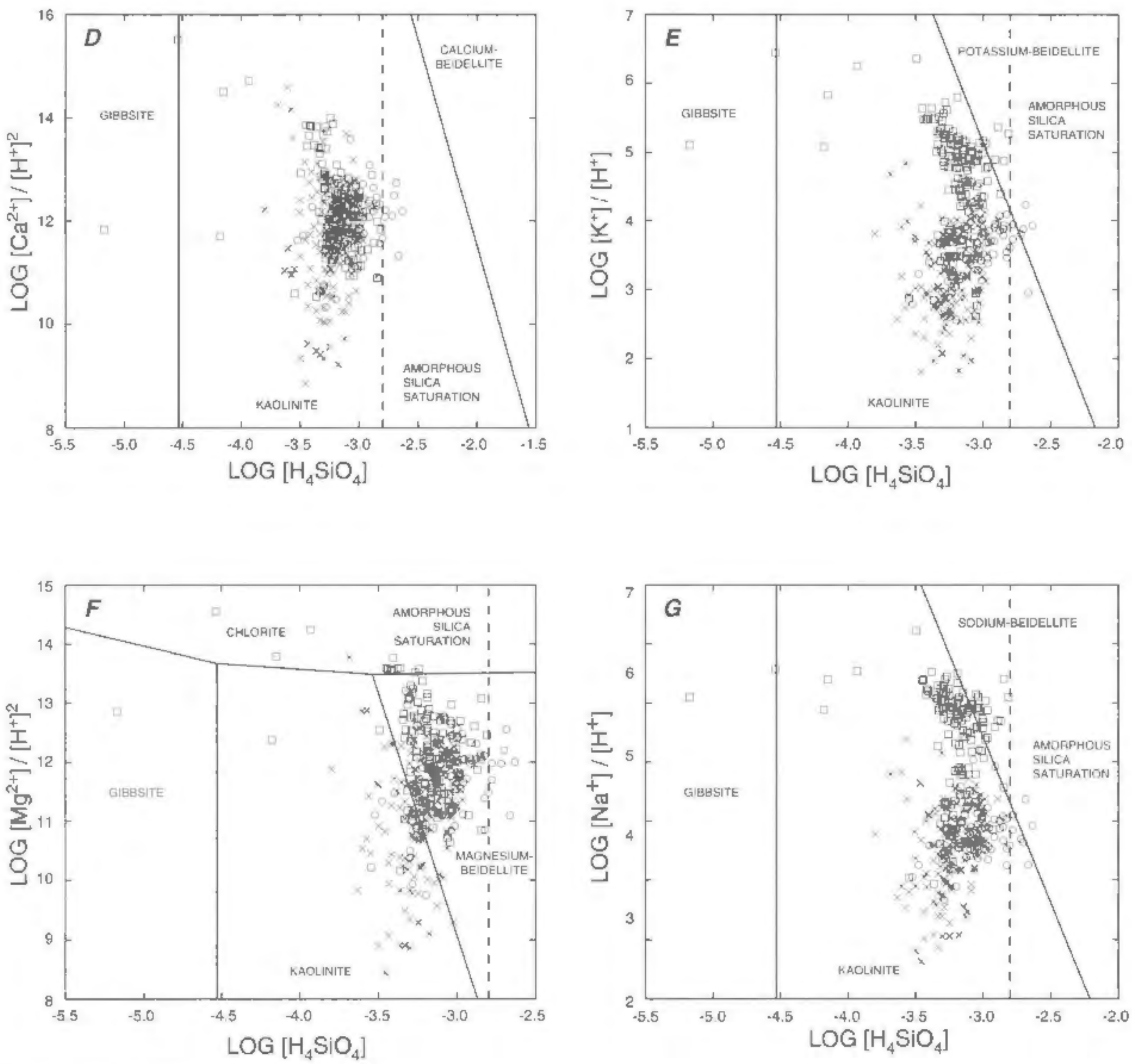


Figure 30. Continued.

relation to human activities. A comparison of ranked concentrations shows some significant differences between these two land-use groups (table 12, fig. 32). Ground water beneath agricultural areas has significantly higher ranked concentrations of arsenic, boron, fluoride, and molybdenum than ground water from urban areas. In contrast, ranked chloride, iron, lithium, and nitrate concentrations in ground water beneath urban land are significantly higher.

Differences in ground-water quality between the agricultural and urban areas may be caused by human activities. Shallow ground water beneath both areas is largely recharged by surface irrigation. Higher chloride, nitrate, and iron beneath the urban areas could be a result of human activities common in urban environments. For example, higher chloride concentrations could result from winter application of salt on roads. Higher nitrate could result from fertilizers and sewage. Higher iron concentrations can be an indirect result of release of synthetic organic compounds to the ground water. Synthetic organic compounds released to the shallow subsurface can react with oxygen, producing anoxic conditions. As discussed in the following section, a rise in the water table from landscape and agricultural irrigation can cause reaction of

Table 11. Statistical comparison of ranked concentrations of minor constituents and dissolved oxygen in water from principal aquifers and water from upland and shallow aquifers of Carson River Basin, Nevada and California

[Constituents in **bold** and nonbold have, respectively, higher and lower ranked concentrations in principal aquifers: p-values determined by Mann-Whitney method (Conover, 1980, p. 216)]

Aquifer system	Highly significant (p less than 0.01)	Significant (p greater than 0.01 and less than or equal to 0.05)	Not significant (p greater than 0.05)
		Carson and Eagle Valleys	
Upland	**Boron, fluoride**	Iron	Arsenic, lithium, manganese, molybdenum, nitrate, vanadium, dissolved oxygen
Shallow	Iron, manganese, lithium	Boron	Arsenic, fluoride, molybdenum, nitrate, vanadium, dissolved oxygen
		Carson Desert	
Shallow	**Iron**, manganese, nitrate,molybdenum	Lithium, dissolved oxygen	Arsenic, boron, fluoride, vanadium

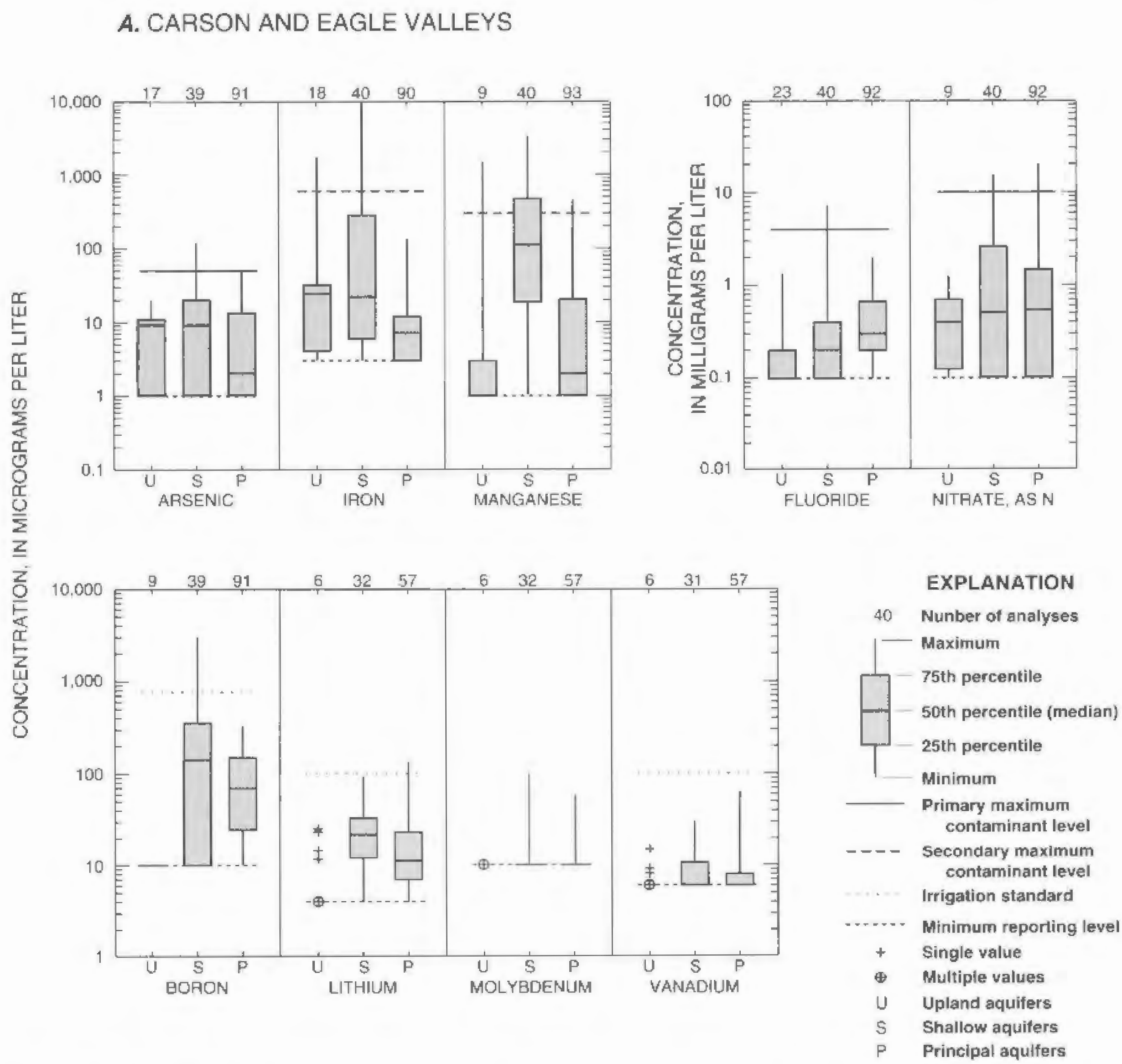


Figure 31. Boxplots showing summary statistics for minor constituents in aquifer systems of Carson River Basin, Nevada and California. *A*, Carson and Eagle Valley; and *B*, Carson Desert.

Table 12. Statistical comparison of ranked concentrations of minor constituents and chloride beneath agricultural and urban land of upper Carson River Basin, Nevada and California

[Constituents in **bold** and nonbold have, respectively, higher and lower ranked concentrations in ground water beneath urban land; p-values determined by Mann-Whitney method (Conover, 1980, p. 216)]

Highly significant (p less than 0.01)	Significant (p greater than 0.01 and less than or equal to 0.05)	Not significant (p greater than 0.05)
Arsenic, boron, **chloride, iron**	Fluoride, **lithium,** molybdenum, **nitrate**	Manganese, vanadium

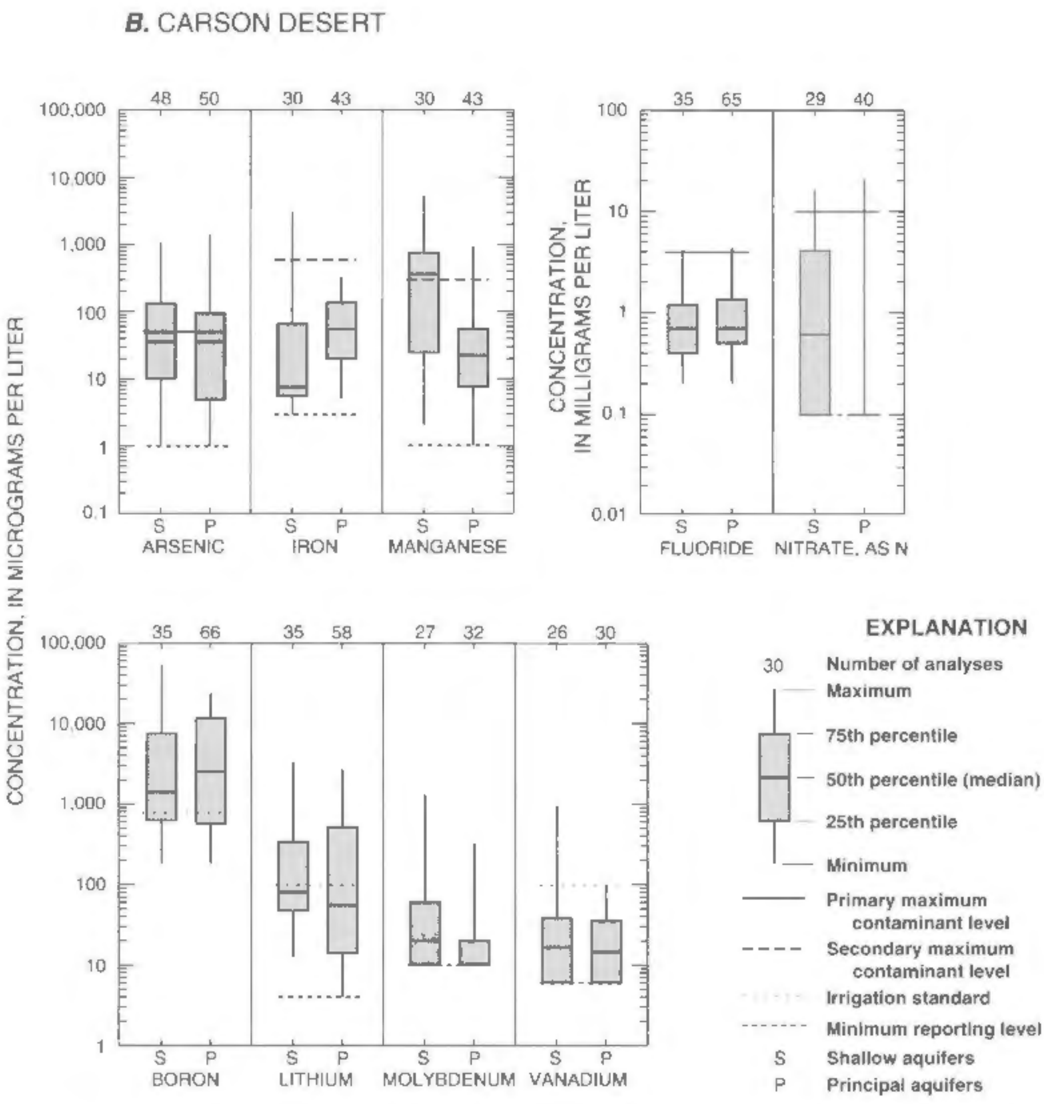


Figure 31. Continued.

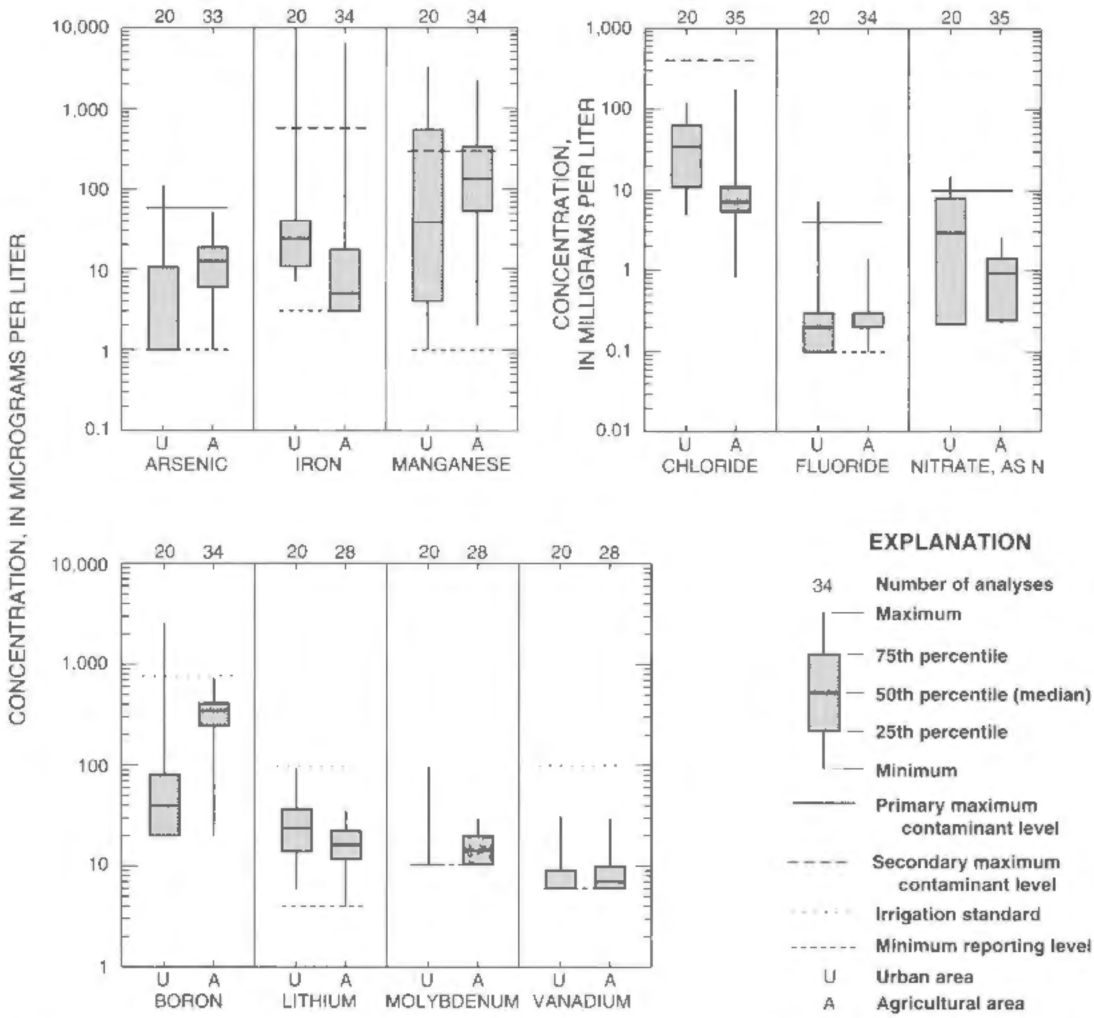


Figure 32. Summary statistics for minor constituents and chloride in shallow aquifers beneath agricultural and urban land of the upper Carson River Basin, Nevada and California.

sedimentary organic matter, producing water that contains little or no dissolved oxygen. Iron is much more soluble in water without dissolved oxygen.

The differences in ground-water quality may be due to factors unrelated to human activities. One complicating factor is that the urban samples are located only in Eagle Valley whereas the agricultural samples are from wells in Carson Valley. The lack of analyses of samples collected prior to urban and agricultural land use prevents an evaluation of whether the differences are related to land use or other factors.

Water in principal aquifers of the upper and middle Carson River Basin generally contains lower concentrations of minor constituents than in the lower basin (Carson Desert), as shown in figure 33. Although some constituents have significantly higher ranked concentrations in ground water from the middle than from the upper basin (table 13), concentrations generally are below standards and guidelines (fig. 33).

Several minor constituents in ground water of Carson Desert commonly are highly concentrated, both relative to upstream parts of the basin and compared to standards and guidelines (table 13, fig. 33). Arsenic, boron, lithium, and molybdenum concentrations exceed standards and guidelines in more than 25 percent of samples from aquifers in Carson Desert. The sole source of drinking water for Fallon and the Fallon Naval Air Station is a basalt aquifer containing arsenic concentrations slightly higher than the 50 µg/L standard. Ranked concentrations of arsenic, boron, fluoride, iron, lithium, manganese, molybdenum, and nitrate are significantly higher in ground water in Carson Desert than in the upper and middle basin (table 13).

Table 13. Statistical comparison of ranked concentrations of minor constituents in ground water from upper, middle, and lower Carson River Basin, Nevada and California

[Constituents in **bold** and nonbold have, respectively, higher and lower ranked concentrations in more downstream part of basin; p-values determined by Mann-Whitney method (Conover, 1980, p. 261). Symbol: --, no constituent]

Area	Highly significant (p less than 0.01)	Significant (p greater than 0.01 and less than or equal to 0.05)	Not significant (p greater than 0.05)
	Principal aquifers		
Carson and Eagle Valleys compared with Dayton and Churchill Valleys	**Boron, iron, vanadium**	**Lithium, manganese, dissolved oxygen**	Arsenic, fluoride, molybdenum, nitrate
Dayton and Churchill Valleys compared with Carson Desert	**Arsenic, boron, fluoride, iron, lithium, molybdenum, nitrate**	**Manganese**	Vanadium, dissolved oxygen
Carson and Eagle Valleys compared with Carson Desert	**Arsenic, boron, fluoride, iron, lithium, manganese, molybdenum, nitrate, vanadium**, dissolved oxygen	--	--
	Shallow aquifers		
Carson and Eagle Valleys compared with Carson Desert	**Arsenic, boron, fluoride, lithium, molybdenum, vanadium**, dissolved oxygen	--	Iron, manganese, nitrate

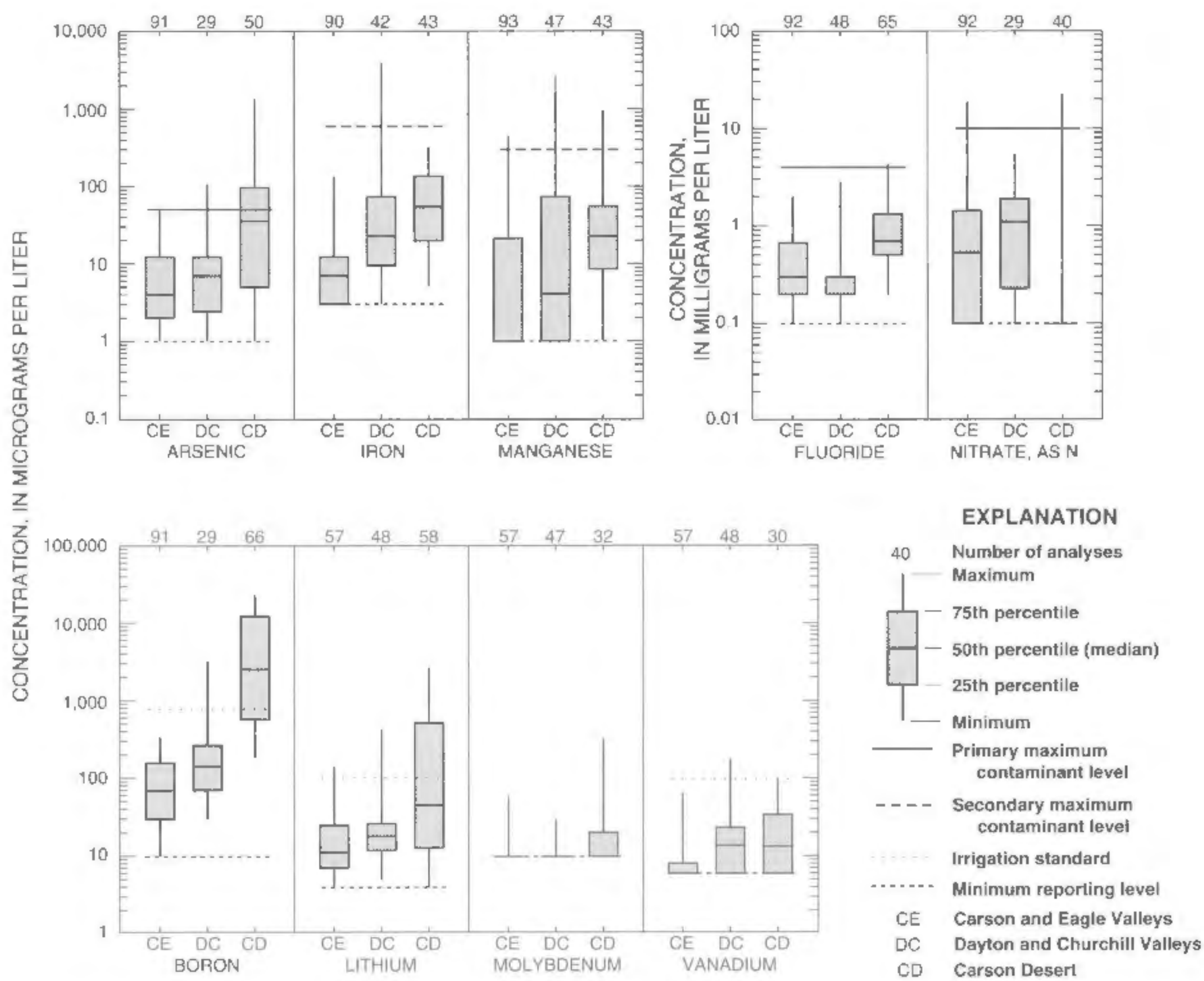


Figure 33. Summary statistics for minor constituents in principal aquifers in Carson River Basin, Nevada and California.

In Carson Desert, shallow aquifers have significantly higher ranked concentrations of manganese, nitrate, molybdenum, and lithium than those found in principal aquifers (fig 31*B*, table 11) Iron, fluoride, nitrate, and vanadium concentrations do not exceed standards and guidelines in principal and shallow aquifers (fig 31*B*)

Among constituents with MCL's, arsenic most commonly exceeds the standard in ground water of the Carson River Basin Most constituents that exceed MCL's in the basin are in shallow aquifers of Carson Desert (fig 34) Concentrations of dissolved arsenic in shallow aquifers locally differ greatly over short vertical and horizontal distances Differences are greatest in irrigated areas in Carson Desert For example, measured arsenic concentrations at Dodge Ranch increase from about 10 μg/L in irrigation water recharging the shallow aquifer to more than 2,000 μg/L in water at depths less than 20 ft below land surface (fig 35*A*) In areas of upward flow from intermediate to shallow aquifers, such as near Lead Lake, arsenic concentrations also are high (fig 35*B*), but the range is somewhat less In this area, measured arsenic concentrations differ by a factor of 2 9 and range from 480 to 1,400 μg/L

Manganese concentrations greater than the SMCL are found in ground water throughout much of the Carson River Basin (fig 36) Water with concentrations in excess of the drinking-water standards is most common in shallow aquifers of the upper and lower basin (fig 31) Shallow aquifers beneath urban and agricultural land in the upper basin contain high manganese concentrations (fig 32)

During the late 1800's to early 1900's, 7,000 tons of mercury was released to the environment during milling and amalgamation of gold and silver ore from the Comstock Lode in the Virginia City and Gold Hill areas (Smith, 1943, p 257) Much of this mercury and associated mine tailings were washed into the Carson River, resulting in contaminated river sediments downstream from the Comstock As a result of this contamination, a public health warning for human consumption of fish caught in Lahontan Reservoir was issued in 1986 by the Nevada Bureau of Health Protection Services A public health warning also was issued in March 1989 for consumption of shoveler duck muscle from the Carson Lake area High concentrations of mercury in sediment samples from Lahontan Reservoir and the Carson River have been documented by Van Denburgh (1973), and from Carson Lake and depositional areas of the Carson River in Carson Desert by Hoffman and others (1990) Surficial soil samples from Carson Desert contained high concentrations of mercury, especially along former channels of the Carson River (Tidball and others, 1991) Despite this documented contamination, only very low concentrations of mercury have been found in ground-water samples from Carson Desert (Hoffman and others, 1990, Lico and Seiler, 1994) and from Dayton and Churchill Valleys (Thomas and Lawrence, 1994) A recent summary of ground-water data in the Carson River Basin (Welch and others, 1989) showed that mercury concentrations did not exceed or closely approach established MCL's

Analyses of ground water compiled for this study generally show low selenium concentrations A few samples collected in Carson Desert during studies of irrigation drainage (Hoffman and others, 1990, p 36, Rowe and others, 1991, table 33) had selenium concentrations greater than the 10 μg/L MCL However, these samples were from monitoring wells in shallow aquifers near Stillwater Wildlife Management Area where ground water is not used for human consumption The Bureau of Reclamation studied selenium in shallow ground water and surface drains in the Fallon Indian Reservation and found high concentrations very localized (Bureau of Reclamation, 1987b) Extensive studies of surface-water quality, particularly with respect to selenium, have been completed in Carson Desert (Hoffman and others, 1990, Rowe and others, 1991, Lico, 1992) These studies show a possible link between selenium and wildlife mortalities or deformities in Carson Desert No apparent relation between selenium concentrations in ground water and in water from a nearby surface drain was observed in Carson Desert (Hoffman and others, 1990)

Processes Producing Concentrations of Minor Constituents
***By* Alan H Welch**

Chemical reduction caused by reaction with sedimentary organic matter can lead to dissolution of metal oxides and conversion of nitrate to less oxidized species Organic matter is microbially oxidized, resulting in electrons being accepted by some oxidized species that are thereby reduced The reduction of both dissolved chemical species and solid phases typically present in alluvial aquifers can proceed in an order estimated by thermodynamics A commonly described sequence involving closed-system reactions in the presence of sedimentary organic matter from a more

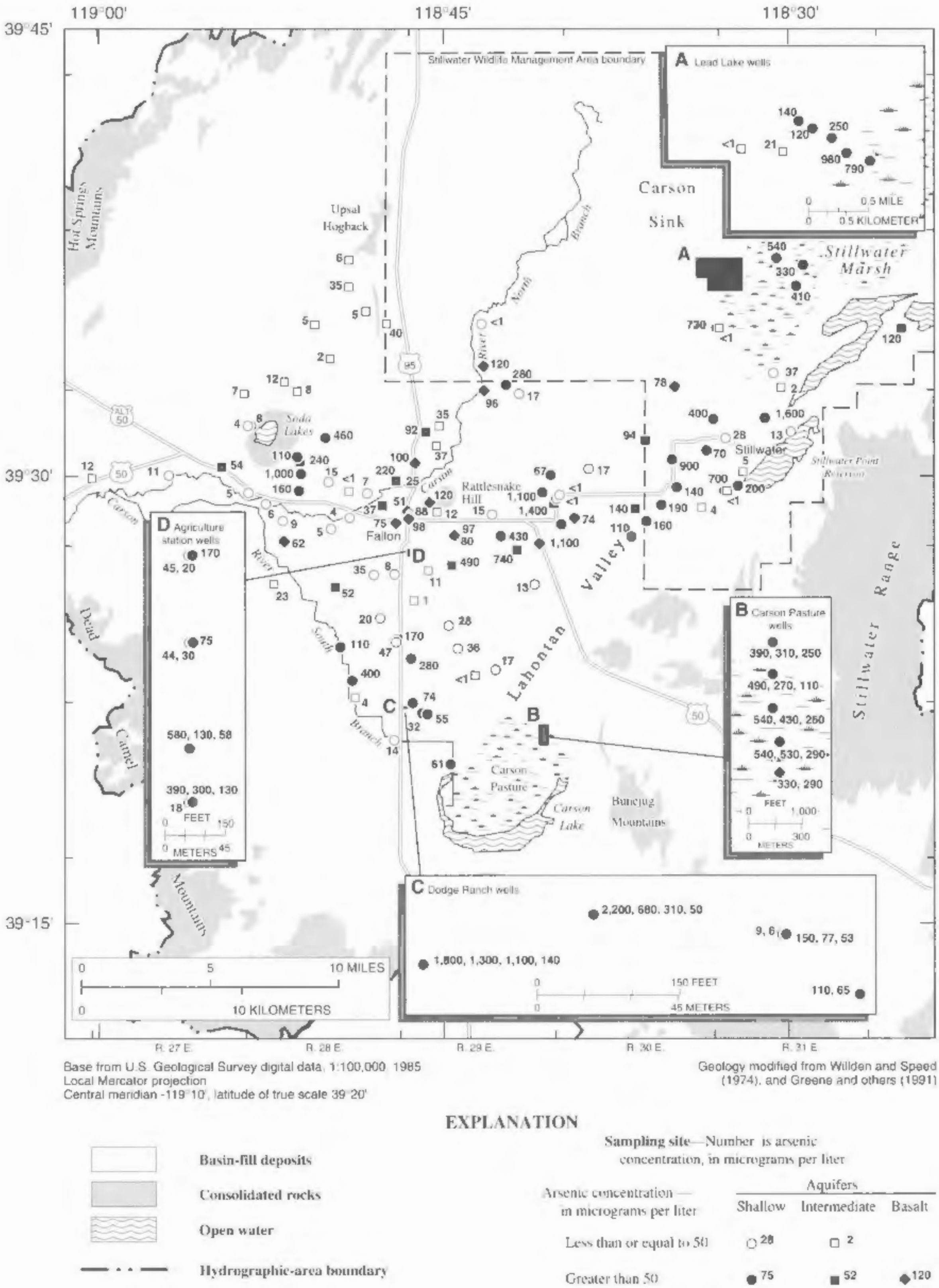


Figure 34. Ground-water sampling sites in southern Carson Desert, Nevada, where arsenic concentrations exceed Nevada State drinking-water standard (50 micrograms per liter).

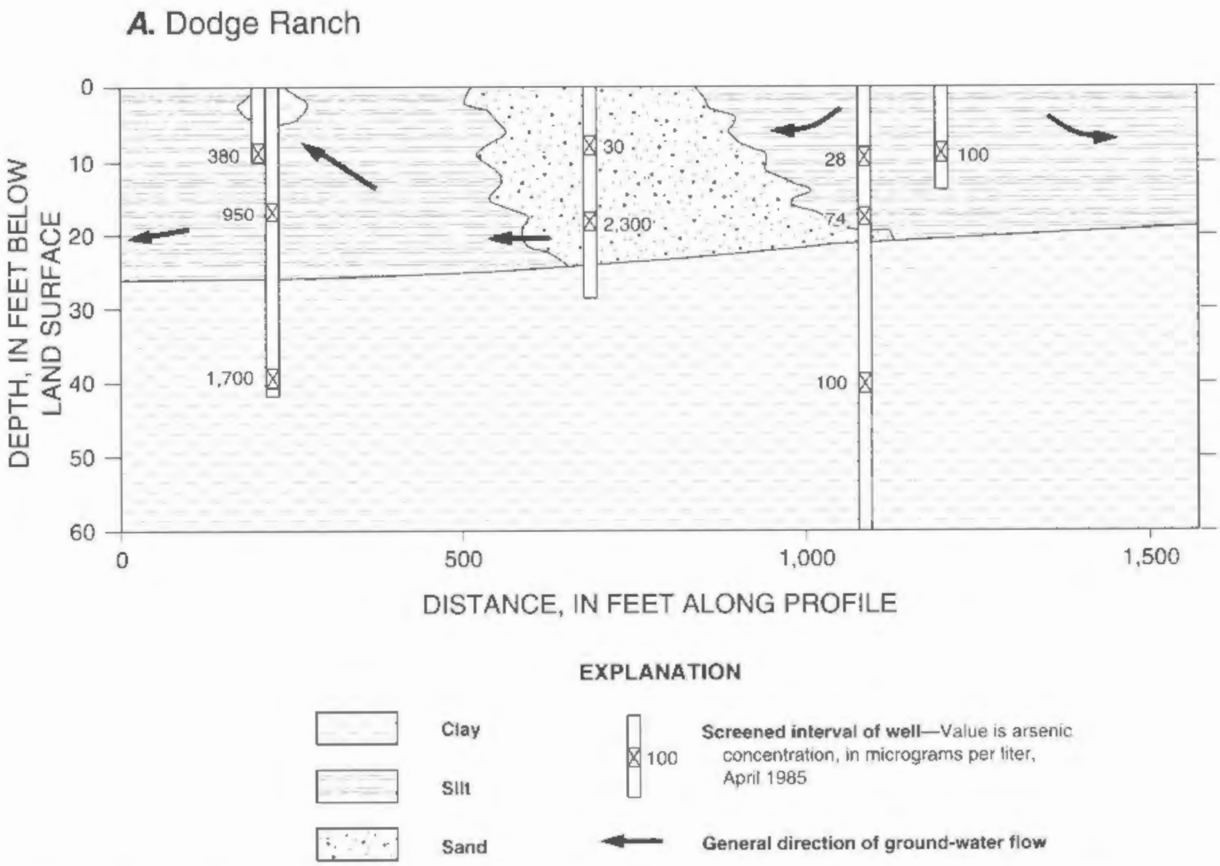


Figure 35. Arsenic concentrations in shallow ground water at two sites in southern Carson Desert, Nevada. *A*, Dodge Ranch; and *B*, Lead Lake.

oxidized to a more reduced state is (1) consumption of dissolved oxygen, (2) reduction of nitrate to nitrogen gas (denitrification), (3) dissolution of manganese oxide, (4) dissolution of iron oxide, (5) reduction of dissolved sulfate to sulfide, and (6) conversion of dissolved nitrogen gas to ammonia (Champ and others, 1979, table 2). These reactions can lead to release of other minor constituents, including arsenic, molybdenum, and uranium, if these constituents are present in sedimentary organic matter or iron and manganese oxides.

Adsorption can limit dissolved concentrations for some inorganic constituents, particularly those generally found at trace levels, such as arsenic. Because a critical discussion of models developed to quantitatively describe adsorption and the results of laboratory experiments is beyond the scope of this report, readers are referred to Davis and Hayes (1986). Briefly, adsorption is a process in which a dissolved species becomes attached to a surface of a pre-existing solid phase. An important phenomenon found in laboratory studies is the pH-dependence of adsorption. Over a narrow pH range, adsorption of ions varies from very little to nearly complete. Additionally, cations are adsorbed at higher pH values and anions are adsorbed at lower pH values. Some phases commonly found in alluvial deposits, such as iron oxides, can have a negative surface charge in solutions with pH values of about 8 or greater. Anions such as fluoride, arsenic, and molybdenum also commonly tend to be only weakly adsorbed on iron oxides in alkaline solutions. These phenomena are consistent with the electrostatic model of James and Healy (1972). Adsorption has been described as both an electrostatic interaction between an oxide surface and an adsorbing species (James and Healy, 1972) and as formation of a complex on the surface. The latter interaction is commonly called "specific" adsorption. These two ideas are combined in a single model containing terms for both interactions (Davis and others, 1978), where either can dominate.

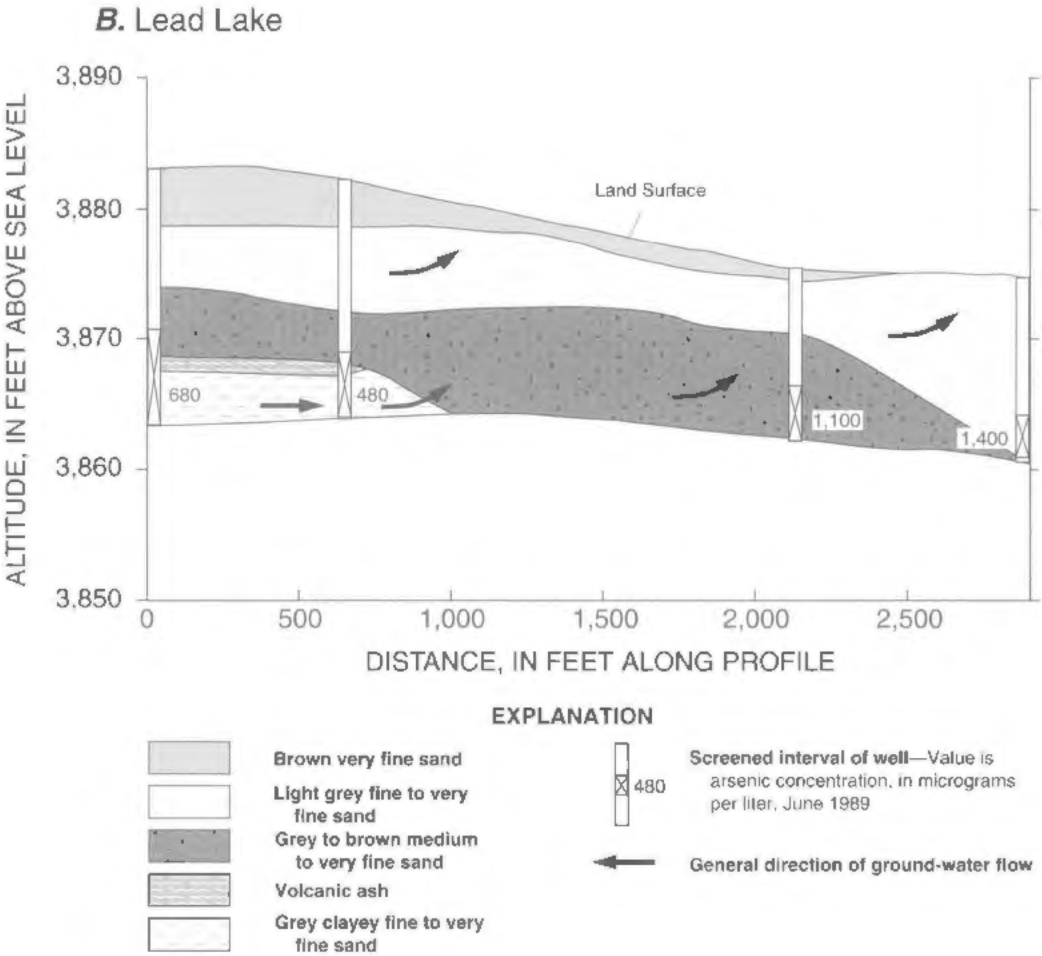


Figure 35. Continued.

Median concentrations of iron and manganese in shallow sediment sampled from the Carson River Basin are similar to estimated average concentrations in granitic rocks and somewhat lower than in basalt (table 14). These granitic and basalt rock types form much of the uplands, except for the ranges surrounding Carson Desert. Iron and manganese in unaltered granitic and basaltic rocks are mostly in mafic minerals, including amphiboles and pyroxenes. These groups of minerals generally are unstable in weathering environments. Weathering of these mafic minerals in oxygenated environments, such as streams and some ground water, results in formation of oxides on fractures and sediment surfaces. Ferric oxyhydroxides (FeOOH) and birnessite (MnO_2) are common in sediments. These oxides, which form part of total concentrations in sediments, can dissolve if they come in contact with water containing a chemically more reduced specie, such as dissolved organic carbon. For example, inundation of sediments containing organic matter can result in dissolution of the oxides.

Manganese and iron concentrations are weakly correlated (Spearman's rho is equal to 0.39), suggesting that ground water with a high concentration of manganese also may have a high concentration of iron (fig. 37*A*). Higher concentrations of both manganese and iron are found in water with low dissolved-oxygen concentrations (figs. 37*B* and *C*) and high dissolved-organic-carbon concentrations (figs. 37*D* and *E*). Manganese and iron concentrations greater than about 100 µg/L generally are in water with dissolved-oxygen concentrations less than 2 mg/L. High dissolved organic carbon and low dissolved oxygen are consistent with oxygen in recharge water reacting with organic carbon to produce a slightly reduced ground water. Pumping of wells during sampling may introduce oxygen into water prior to determination of the

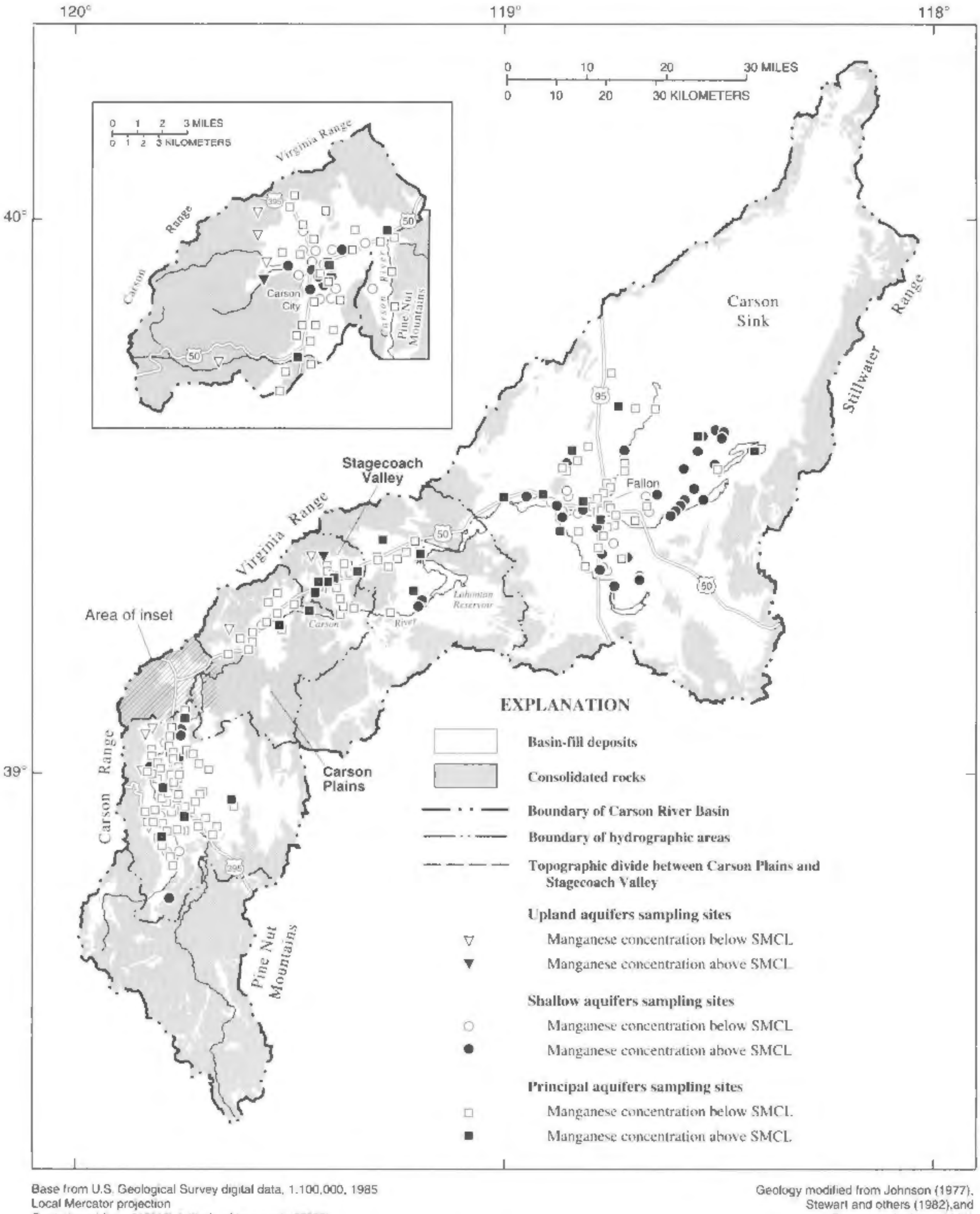


Figure 36. Ground-water sampling sites in Carson River Basin, Nevada and California, where concentrations of manganese exceed Nevada State secondary maximum contaminant level (100 micrograms per liter). SMCL, secondary maximum contaminant level.

dissolved oxygen Consequently, water with a measured low dissolved-oxygen concentration (less than about 2 mg/L) may have even lower concentrations in an aquifer

Dissolved organic carbon in anoxic water can react with iron and manganese oxides on aquifer material, thereby producing water with high concentrations of these two metals Reaction of dissolved organic carbon with iron and manganese oxides is consistent with the geologic and hydrologic regime in the shallow subsurface of the Carson River Basin This reaction probably occurs in shallow aquifers from which most of the ground-water samples with high concentrations of iron and manganese were obtained

Sediments forming shallow aquifers consist primarily of alluvial and colluvial deposits that generally have oxide coatings (Jenne, 1968) Irrigation of agricultural and urban land has raised the water table, resulting in saturation of previously unsaturated sediments, particularly in southern Carson Desert This change in water level apparently has resulted in release of sedimentary organic matter to the ground water Sedimentary organic matter reacts with oxygen in recharge water and with oxide coatings on aquifer materials High iron and manganese concentrations are common in the resulting anoxic water Thus, water with high iron and manganese concentrations in shallow aquifers can be an indirect result of a rise in the water table by recharge from agricultural and urban activities

Ground water in the Carson River Basin with high manganese and iron concentrations (greater than 100 μg/L) generally is at or near saturation with the carbonate minerals rhodochrosite and siderite (figs 38*A* and *B*) Although these minerals have not been identified as discrete phases in the basin-fill sediments, they have been shown to form in nonmarine water Siderite has been identified as a secondary mineral formed by precipitation from ground water in shallow sediments (Magaritz and Luzier, 1985) and rhodochrosite has been reported in aquifers from several localities (Jones and Bowser, 1978, p 215-219) Iron and manganese can adsorb onto calcite surfaces or, at high metal concentrations, form iron or manganese carbonate minerals, as shown by laboratory experiments for manganese (Zachara and others, 1991) Iron and manganese carbonate, either as discrete minerals or on calcite surfaces, appear to limit metal concentrations in some ground water that has low concentrations of dissolved oxygen

Among constituents with MCL's, arsenic is found most commonly at concentrations exceeding the standard, particularly in Carson Desert Median arsenic concentrations in surficial sediments of the Carson

Table 14 Concentrations of selected constituents in shallow sediments of Carson River Basin, Nevada and California, and Western United States, and estimated mean concentrations in selected rock types

[Units of measure milligrams per kilogram (equivalent to parts per million) Symbol --, values not available]

Constituent	Shallow sediments					Estimated means			
	Carson River Basin [1]			Western United States [2]		Granite [3]	Basalt[3]	Sandstone [4]	Shale[4]
	Geometric			Geometric					
	Median	Mean	Maximum	Mean	Maximum				
Iron	30,000	29,000	68,000	26,000	100,000	27,000	86,000	18,600	38,800
Manganese	630	600	1,500	480	5,000	500	1,700	392	575
Fluoride	--	--	1,900	440	1,900	850	400	220	500
Boron	6 1	7 2	300	29	300	15	5	90	194
Lithium	37	41	130	25	130	30	12	15	46
Arsenic	10	10	73	7 0	97	1 5	2	1	7
Molybdenum	8	9	7	1 1	7	1 5	1	5	4 2
Uranium	3 3	3 7	490	2 7	7 9	4 8	6	1	4 5

[1] E A Frick (U S Geological Survey, written commun , 1992), modified from Tidball and others (1991)
[2] Shacklette and Boerngen (1984, table 2), geometric mean is estimated
[3] Taylor (1964)
[4] Horn and Adams (1966)

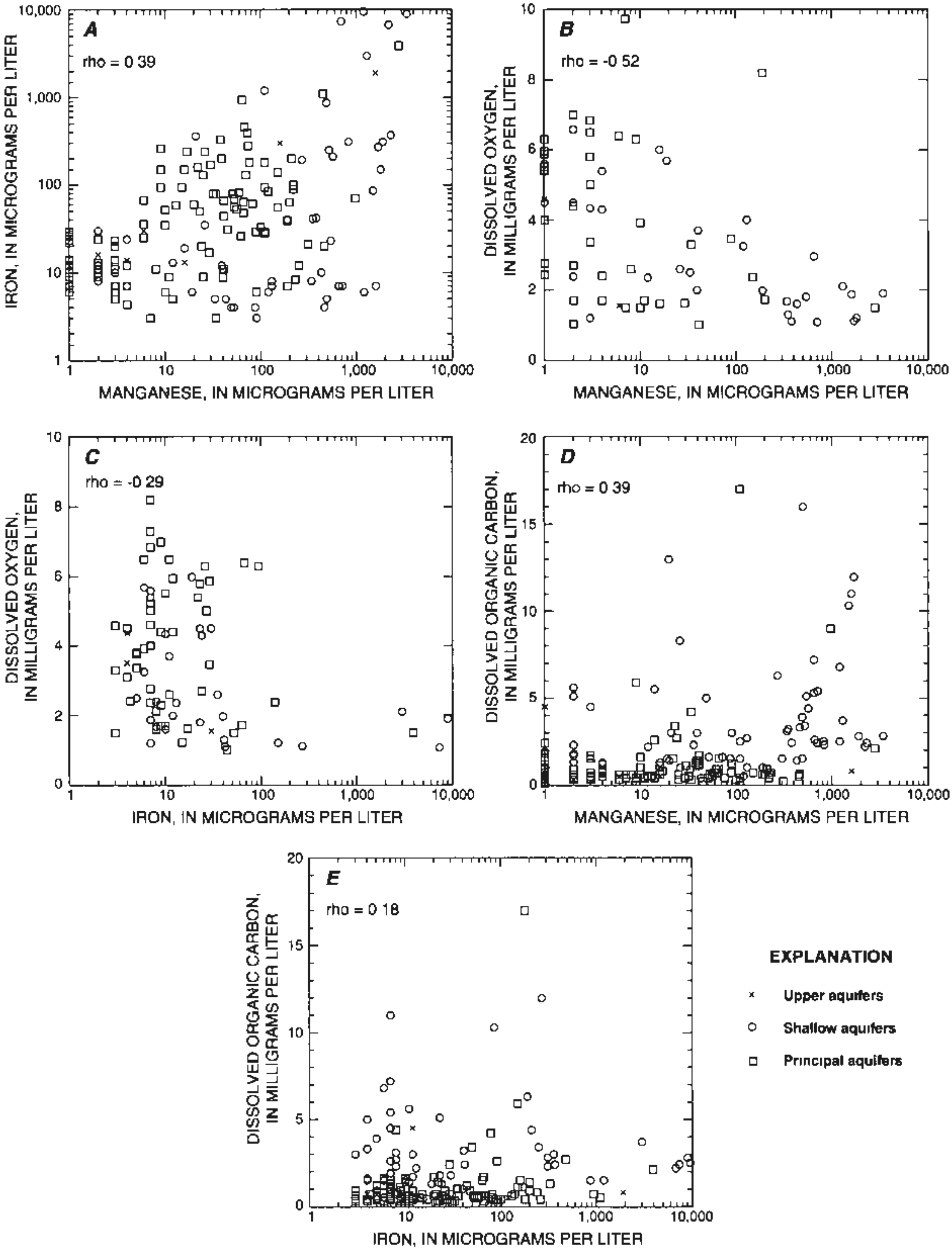


Figure 37 Relations between selected minor constituents in ground water of Carson River Basin, Nevada and California *A*, Manganese and iron, *B*, Manganese and dissolved oxygen, *C*, Iron and dissolved oxygen, *D*, Manganese and dissolved organic carbon, and *E*, Iron and dissolved organic carbon The rho value is Spearman's rho test statistic (Iman and Conover, 1983, p 126-129)

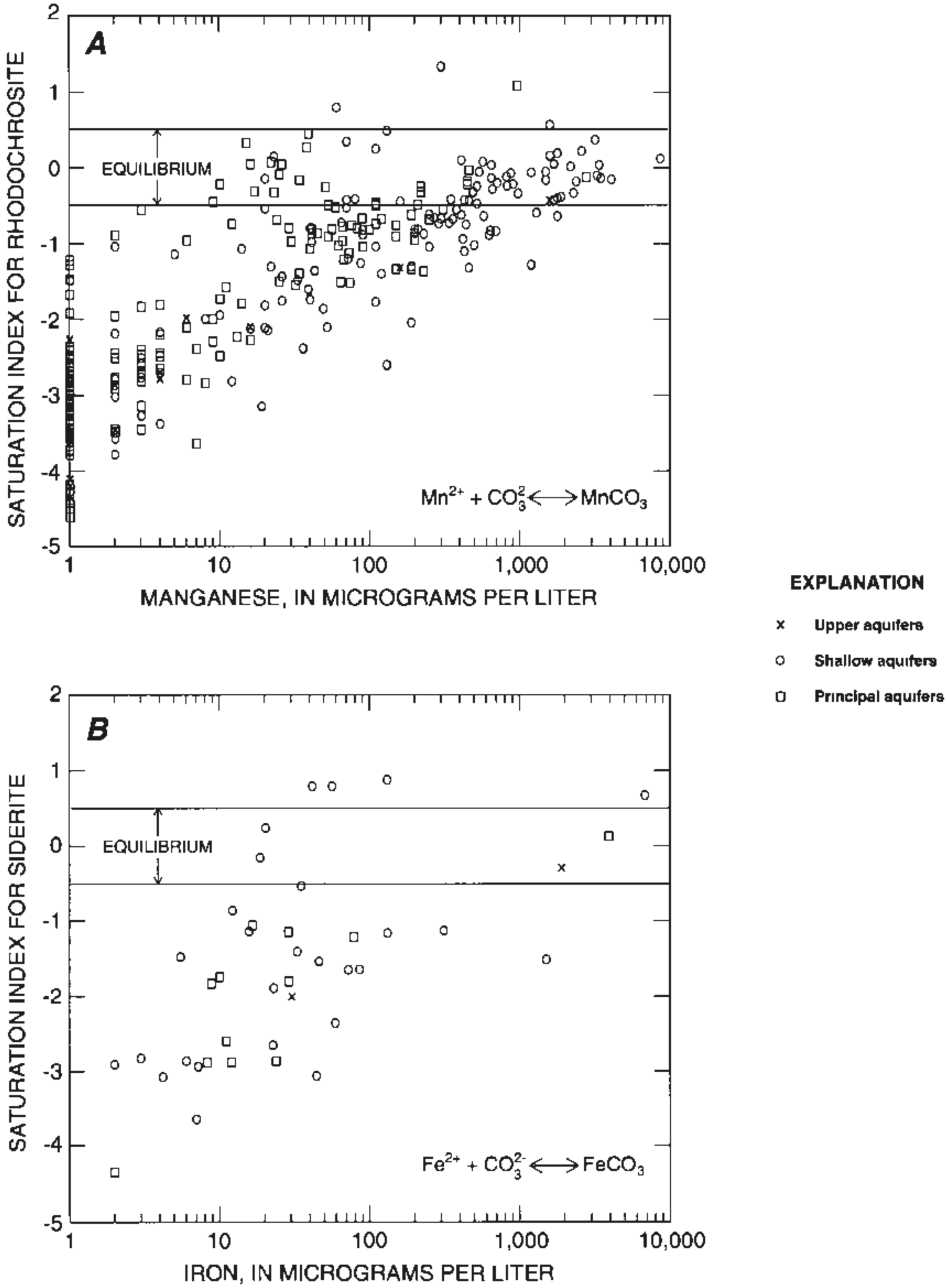


Figure 38 Relations between (*A*) manganese and the saturation index for rhodochrosite, and (*B*) iron and the saturation index for siderite in ground water of Carson River Basin, Nevada and California The rho value is Spearman's rho test statistic (Iman and Conover, 1983, p 126-129)

River Basin are greater than estimated average values for both granitic and basaltic rocks (table 14) Arsenic concentrations in surficial sediments also are greater in Carson Desert than in Carson and Eagle Valleys (E A Frick, U S Geological Survey, written commun , 1992) The estimated geometric mean concentration in surficial sediments in the Western United States and the estimated average concentration in shale are similar to median values for the Carson River Basin (table 14)

Arsenic concentrations in some ground water beneath Dodge Ranch (fig 35*A*) are much greater than can be attributed to evaporative concentration as shown by the relation between arsenic and chloride (fig 39) Assuming an initial arsenic and chloride concentration equal to that in the sample from Dodge Ranch with the lowest chloride concentration (24 mg/L), the effect of evaporative concentration is shown by the sloping line in figure 39 Water from two wells open to the aquifer at a depth of about 20 ft below land surface clearly have higher arsenic concentrations that can be attributed to evaporative concentration alone

Although the contribution from different solid phases to the total dissolved-arsenic concentration in water cannot be quantified, several processes that release arsenic to the aqueous system can be described Dissolution of ferric oxyhydroxide and manganese oxides, which are present as coatings on the sediments and can concentrate arsenic, is indicated by relatively high concentrations of dissolved iron and manganese in water samples This process may be the primary cause of the high concentrations in water in the shallow aquifers of the southern Carson Desert Dissolution of lithic volcanic fragments, which have arsenic concentrations greater than 30 mg/kg (Lico and others, 1986, table 6), is another potential source of dissolved arsenic in water Adsorption of arsenic on iron oxides also may limit concentrations in water in parts of the Carson River Basin

The relation between arsenic and chloride (fig 39) in water with chloride concentrations greater than about 200 mg/L can be explained by either the dissolution of chloride salts or a combination of evaporative concentration and loss of arsenic from solution Again using the data for Dodge Ranch as an example, two of the three samples with the highest chloride concentrations plot well below the sloping line that represents the effects of evaporative concentration alone This evidence, along with the stable isotope relations shown in figure 20 for shallow water in the upflow zone, suggest that evaporative concentration and loss

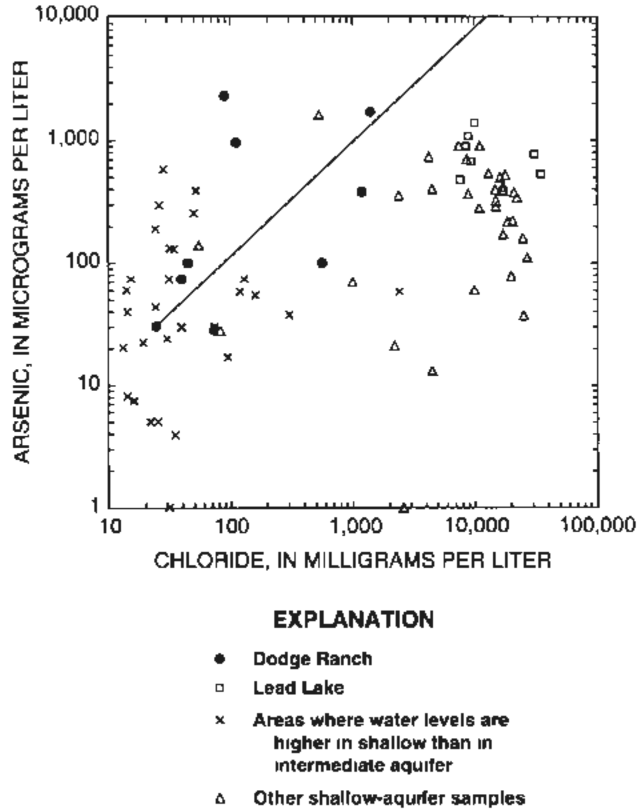


Figure 39 Relation between arsenic and chloride in shallow ground water of Carson Desert, Nevada Sloping line represents composition of water affected only by evaporative concentration, assuming initial chloride and arsenic concentrations of 24 milligrams per liter and 30 micrograms per liter, respectively

of arsenic from solution may be occurring, at least in some shallow ground water The sample with the highest chloride at Dodge Ranch is from a well open to a depth of only 9 ft below land surface The presence of efflorescent salts at this location, which are not present at the other Dodge Ranch locations shown in figure 35*A*, suggests that evaporation affects water at this site

Fluoride concentrations generally are higher in acidic igneous rocks and in residual fluids formed during the cooling of magma than in ground water The estimated mean fluoride concentration in granitic rocks is more than twice that estimated for basalt (table 14) Amphiboles and micas, which are common in a variety of igneous rocks, typically contain some fluoride substituted for hydroxide in crystal lattices Apatite also commonly contains some fluoride Geothermal water typically contains high concentrations of dissolved fluoride commonly contains some fluoride Geothermal water typically contains high concentrations of dissolved fluoride

Geochemical controls on fluoride concentrations in nonthermal ground water commonly are mineral equilibria and adsorption (Hem, 1985, p 121) Two common minerals that contain fluoride, fluorite and fluorapatite, do not appear to limit fluoride concentrations in most ground water of the Carson River Basin (figs 40*A* and *B*) Saturation indices for fluorapatite [$Ca_5(PO_4)_3F$] suggest both oversaturation and undersaturation, which implies that this mineral is not limiting concentrations of fluoride Only a few ground-water analyses show equilibrium or oversaturation with respect to fluorite (CaF_2), suggesting an absence of solubility control

Laboratory and field data indicate that fluoride concentrations can be controlled by adsorption reactions with common minerals Laboratory data show large adsorption capacities for fluoride on minerals such as gibbsite, kaolinite, halloysite, and freshly precipitated aluminum oxide (Bower and Hatcher, 1967) Results of laboratory experiments using iron oxide (goethite) as the sorbing phase show that fluoride is specifically adsorbed Adsorption of a fluoride ion is accompanied by release of a hydroxyl ion, and is less effective with increasing pH (Hingston and others, 1967, 1972) On the basis of a statistical correlation of fluoride with pH, and leachate analyses of aquifer material, Robertson (1985) concluded that adsorption reactions are a likely control on fluoride concentrations in ground water in Arizona's alluvial basins In the Carson River Basin, fluoride concentrations are weakly correlated with pH (fig 40*C*), indicating that adsorption may be limiting concentrations in some ground water

Median concentrations of lithium in surficial sediments are similar to estimated concentrations in shales and to concentrations in sediments of the Western United States (table 14) Boron and molybdenum in sediments of the Carson River Basin have median concentrations lower than those generally found in the Western United States These relations suggest that high dissolved concentrations of these constituents in ground water may be the result of some factor other than total concentrations in the sediments Intense evapotranspiration in Carson Desert, where many of the high concentrations are found, is a likely contributing factor

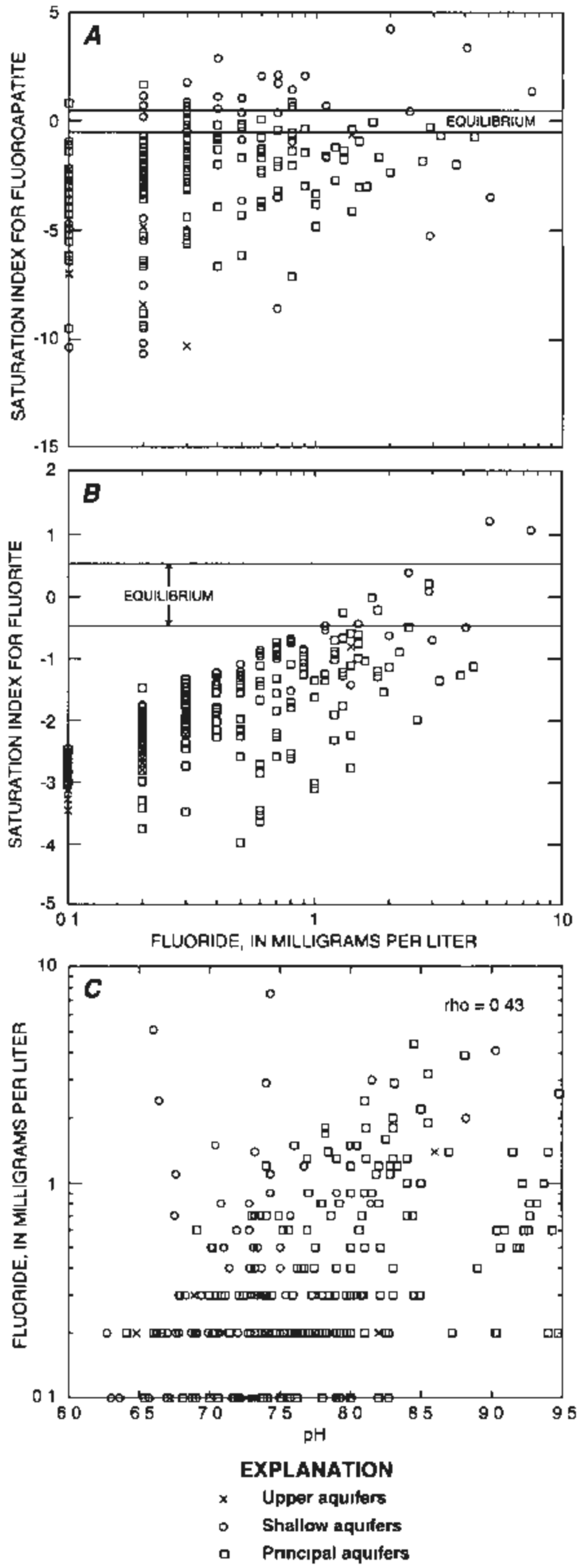


Figure 40 Relation between fluoride concentrations and (*A*) saturation index for fluorapatite, (*B*) saturation index for fluorite, and (*C*) pH in ground water of Carson River Basin, Nevada and California

Radionuclide Activities and Concentrations

By James M. Thomas

Radionuclides of greatest concern in the Carson River Basin, from a human health standpoint, are radon-222 and uranium. This concern is reflected by present and proposed drinking-water standards. Proposed standards for radium-226, radium-228, and adjusted gross alpha (table 6) generally are higher than levels in ground water in the Carson River Basin. The distribution and sources of radionuclides in ground water of the Carson River Basin are described by Thomas and others (1993).

Screening methods have been used for rapid identification of alpha and beta activity in water. These methods, called gross alpha and gross beta, are inexpensive compared to analysis for specific radionuclides and are sensitive to a variety of isotopes. Disadvantages of the methods include (1) volatile radionuclides, including tritium and radon-222, are not detected because samples are dried prior to measurement of the activity, (2) ingrowth of radioactive progeny during the time between sampling and analysis may contribute to gross-beta activity (Thomas and others, 1990, Welch and others, 1995), and (3) the analytical methods do not identify which isotopes contribute to the gross measurement. An additional measure, which has been proposed as a drinking-water standard, is called an "adjusted gross alpha" and is defined as the measured gross-alpha activity minus radium-226 and uranium. Alpha- and beta-emitting isotopes are grouped together in the discussion. Uranium is shown in figure 43 in terms of activity and concentration because the proposed drinking-water standard is expressed as a concentration and the gross-alpha activity is expressed in terms of radioactivity.

Uranium is the primary source of alpha activity in ground water of the Carson River Basin (fig. 41, Thomas and others, 1993). On the basis of a few measurements of the uranium-isotope composition, the activity ratio (AR) of uranium-234 to uranium-238 is within the range of 1 to 1.5. If the only source of alpha activity is uranium, the data will plot along the AR lines shown in figure 41. With only a few exceptions, gross-alpha activity can be accounted for by the uranium present in the water (Thomas and others, 1993). Radium-226, with a maximum measured activity of only 0.56 pCi/L, and thorium-230, with a maximum activity of 0.20 pCi/L, in four samples appear to contribute little to the total alpha activity. Polonium-210 had a maximum activity of 21 pCi/L in one sample, and this may contribute significant alpha activity to some ground water (Thomas and others, 1993).

Gross-beta activity in ground water can be accounted for by potassium-40 and uranium progeny (fig. 42). Potassium concentrations range from about 1 to 500 mg/L (for samples with gross-beta analysis), which correspond to potassium-40 activities ranging from about 0.5 to 410 pCi/L (Thomas and others, 1993). After about 100 days, ingrowth of radioactive uranium progeny produces particle emission rates approximately equal to the initial uranium decay rate, in water with a U-234/U-238 AR equal to 1.0, because one-half of the uranium decay emission would be from uranium-238 decay. Ingrowth of the progeny, combined with potassium-40 activities estimated from potassium concentrations, can produce gross-beta activities that lie along the AR line shown in figure 42. The contribution of radium-228 to gross-beta activities, in most ground-water samples, is small because of low mobility in near-neutral to alkaline water (Krishnaswami and others, 1982, Ames and others, 1983, Latham and Schwarcz, 1987). Median radium-228 activity in ground water of the Carson Desert is less than 1.0 pCi/L (fig. 43*B*).

In the upper basin, principal aquifers contain uranium and radon-222 activities with ranges and medians and ranked activities similar to those found in the

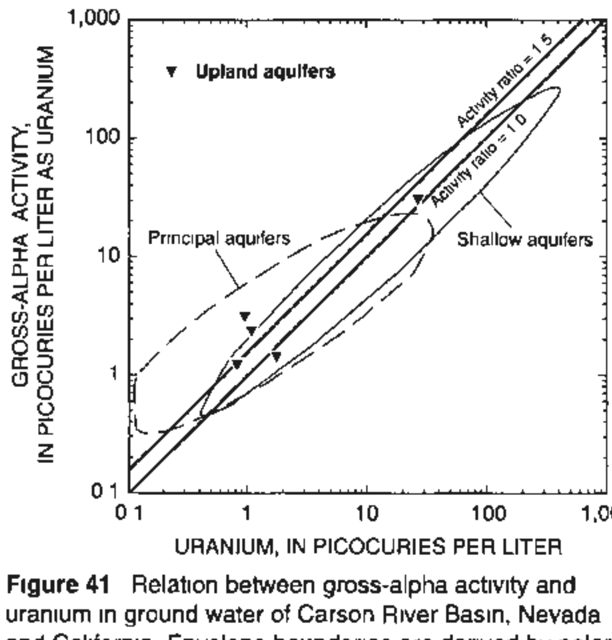


Figure 41. Relation between gross-alpha activity and uranium in ground water of Carson River Basin, Nevada and California. Envelope boundaries are derived by polar smoothing routines and encompass 75 percent of data. Activity ratio is ratio of uranium-234 to uranium-238.

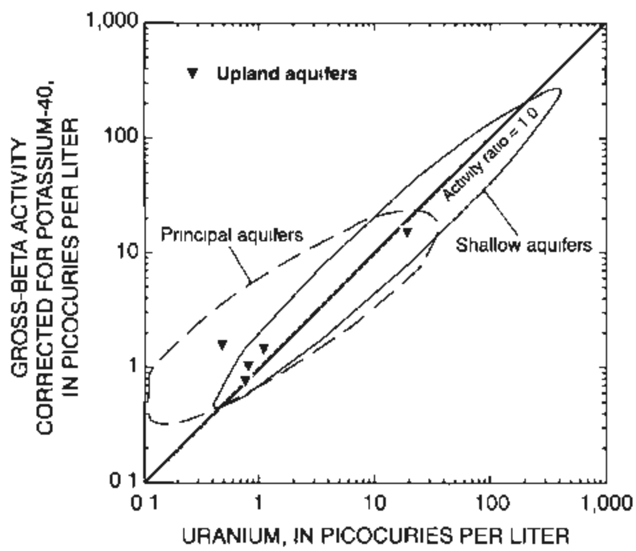


Figure 42 Relation between gross-beta activity and uranium in ground water of Carson River Basin, Nevada and California Envelope boundaries are derived by polar smoothing routines and encompass 75 percent of data

upland and shallow aquifers (fig 43*A*, table 15) The median concentration of uranium in surficial sediments is similar to estimated mean concentration in shale and the mean for sediments in the Western United States (table 14) In Carson Desert, the median uranium activities in ground water is about 30 times greater in shallow aquifers than in intermediate and basalt aquifers (fig 43*B*) The mean rank radon-222 activity of Carson Desert also is significantly higher in the shallow aquifers than in intermediate and basalt aquifers that compose the principal aquifers (table 15)

Median and ranked uranium concentrations in intermediate and basalt aquifers are the lowest in the Carson Desert (table 16) Median values decrease from 2 8 pCi/L in the upper basin to 1 3 pCi/L in Carson Desert Median radon-222 activities decrease from 1,100 to 425 pCi/L (fig 44) Similarly, ranked uranium activities in shallow aquifers are significantly higher in Carson Desert than in the upper and middle basins (fig 43, table 16) The median activity in shallow aquifers of Carson Desert (40 pCi/L) is high compared to all other aquifers in the basin (fig 43) and to the proposed standard (20 pCi/L)

Radium-226 and -228 activities in ground water are similar in upland, shallow, and principal aquifers and in valleys within the Carson River Basin (figs 43 and 44) Radium-226 activities range from a minimum reporting level of 0 02 to 0 56 pCi/L (fig 43) Radium-228 activities range from a minimum reporting level of 1 0 to 4 6 pCi/L (fig 43)

Uranium concentrations greater than the proposed standard are most commonly found in shallow aquifers of Carson Desert and upland and principal aquifers of Eagle Valley (fig 45) By far, the highest concentrations are in shallow aquifers of Carson Desert Like arsenic, uranium concentrations are highly variable over relatively short distances in shallow aquifers in Carson Desert One example at Dodge Ranch is a 10-fold increase in measured concentrations over a horizontal distance of less than 1,000 ft at depths of less than 30 ft below land surface (fig 46*A*) In general, lower concentrations are in water that has moved shorter distances through the subsurface Variations are somewhat less in ground water beneath non-irrigated land, for example near Lead Lake (fig 46*B*) In this area, measured uranium concentrations differ by a factor of about 1 3, from 180 to 240 µg/L

Eighty-seven percent of ground-water samples from principal aquifers (119 samples) have radon-222 activities greater than the proposed MCL (300 pCi/L) The proportion of samples containing radon-222 above the proposed MCL is about the same in the different aquifers The highest radon-222 activities are in upland aquifers Shallow and principal aquifers have higher radon-222 activities in the western parts of Carson and Eagle Valleys adjacent to the Sierra Nevada (fig 47) The highest radon-222 activities generally are along the western parts of Carson and Eagle Valleys adjacent to the Sierra Nevada Radon-222 in ground water on

Table 15. Statistical comparison of ranked uranium concentrations and radon-222 activities in water from principal aquifers and water from upland and shallow aquifers, Carson and Eagle Valleys and Carson Desert, Nevada and California

[Ranked uranium and radon-222 activities are higher in samples from shallow aquifers, p-values determined by Mann-Whitney method (Conover, 1980, p 216) Symbol --, no constituent]

Aquifer system	Highly significant (p less than 0 01)	Not significant (p greater than 0 05)
	Carson and Eagle Valleys	
Upland	--	Uranium, radon-222
Shallow	--	Uranium, radon-222
	Carson Desert	
Shallow	Uranium, radon-222	--

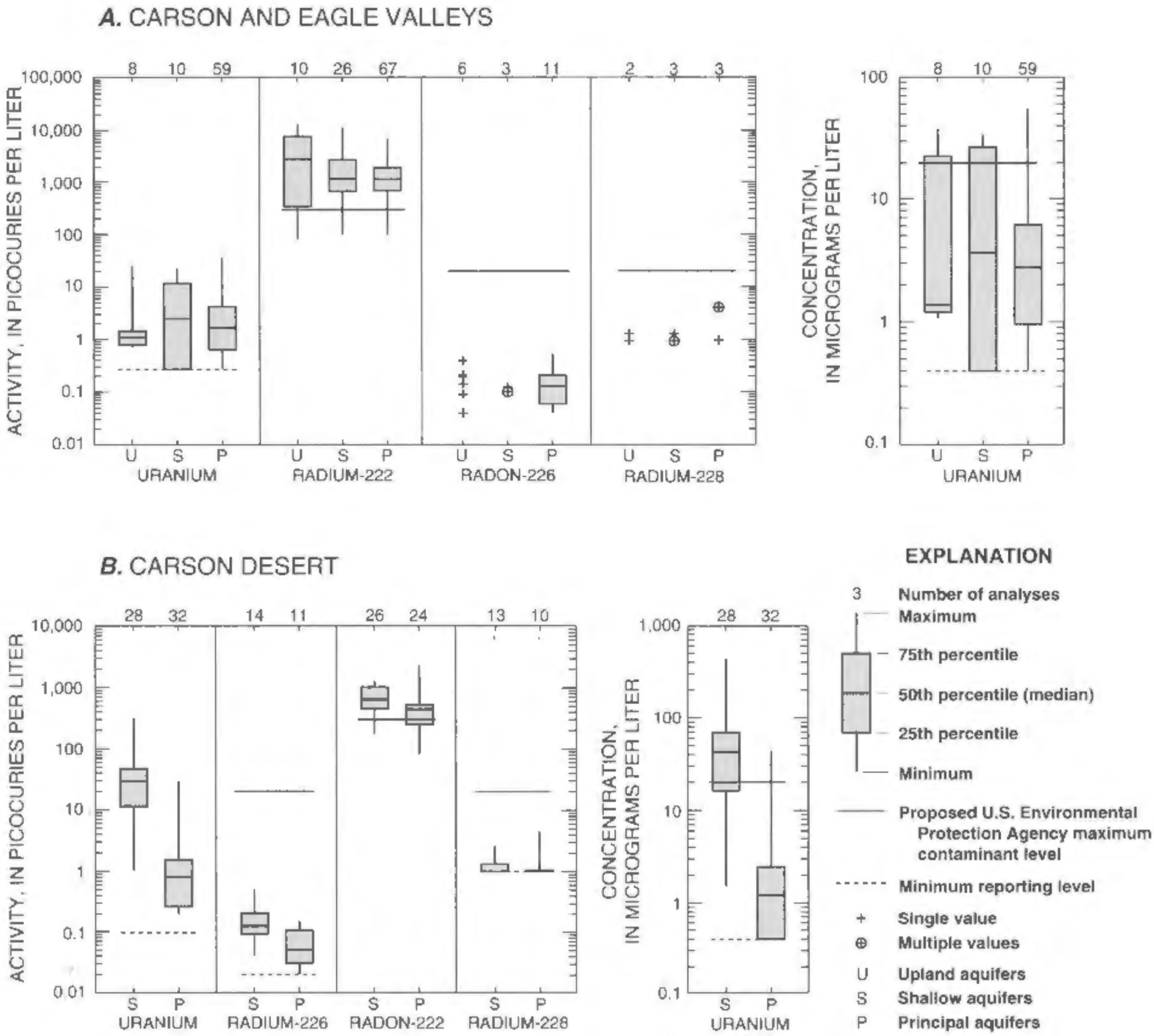


Figure 43. Summary statistics for selected radionuclides in aquifers of (*A*) Carson and Eagle Valleys, and (*B*) Carson Desert, Nevada and California.

the eastern slope of the Carson Range commonly exceeds 2,700 pCi/L and locally has been found as high as 14,000 pCi/L.

More than one-half of 41 samples from shallow aquifers and 3 of 9 samples from upland aquifers have uranium concentrations that exceed the proposed MCL. Most of the samples from the shallow aquifers that exceed the proposed standard (22 of 32) are from wells in Carson Desert. Only 7 of 112 samples from principal aquifers exceed the proposed MCL. Of those seven samples, five are from Carson and Eagle Valleys.

None of the radium-226 or radium-228 samples analyzed exceed the proposed MCL. Four percent of samples (6 of 143) analyzed for gross-alpha activity and dissolved uranium exceed the proposed MCL for adjusted gross alpha.

Processes Producing Radionuclide Activities

***By* Alan H. Welch**

In mountainous areas, uranium is dissolved by water infiltrating granitic rocks, mainly in the Sierra Nevada, and through silicic volcanic rocks in relatively

Table 16. Statistical comparison of ranked uranium concentrations and radon-222 activities in ground water from upper, middle, and lower Carson River Basin, Nevada and California

[Constituents in **bold** and nonbold have, respectively, higher and lower ranked concentrations in more downstream part of basin; p-values determined by Mann-Whitney method (Conover, 1980, p. 216). Symbol: --, no constituent)]

Area	Highly significant (p less than 0.01)	Significant (p greater than 0.01 and less than or equal to 0.05)	Not significant (p greater than 0.05)
		Principal aquifers	
Carson and Eagle Valleys compared with Dayton and Churchill Valleys	Radon-222	--	Uranium
Dayton and Churchill Valleys compared with Carson Desert	Radon-222	Uranium	--
Carson and Eagle Valleys compared with Carson Desert	Uranium, radon-222	--	--
		Shallow aquifers	
Carson and Eagle Valleys compared with Carson Desert	**Uranium**, radon-222	--	--

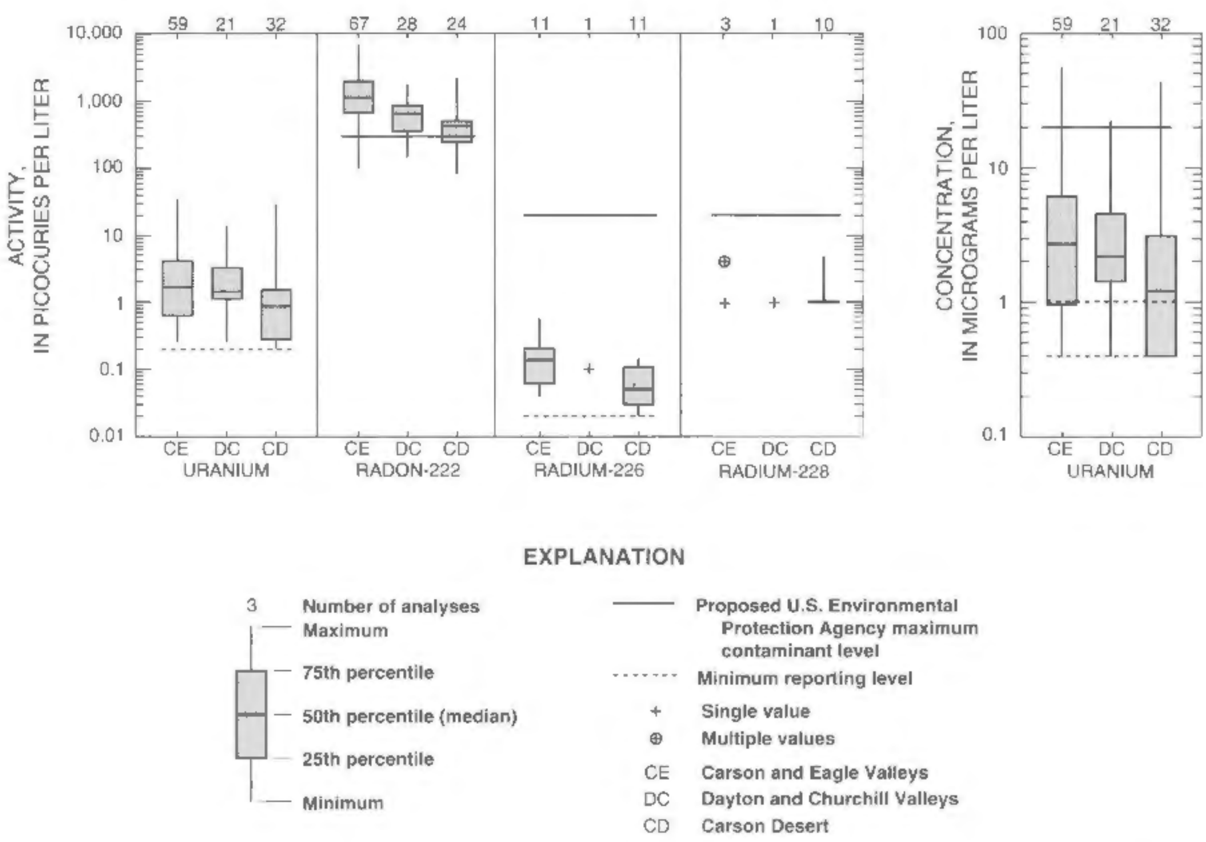
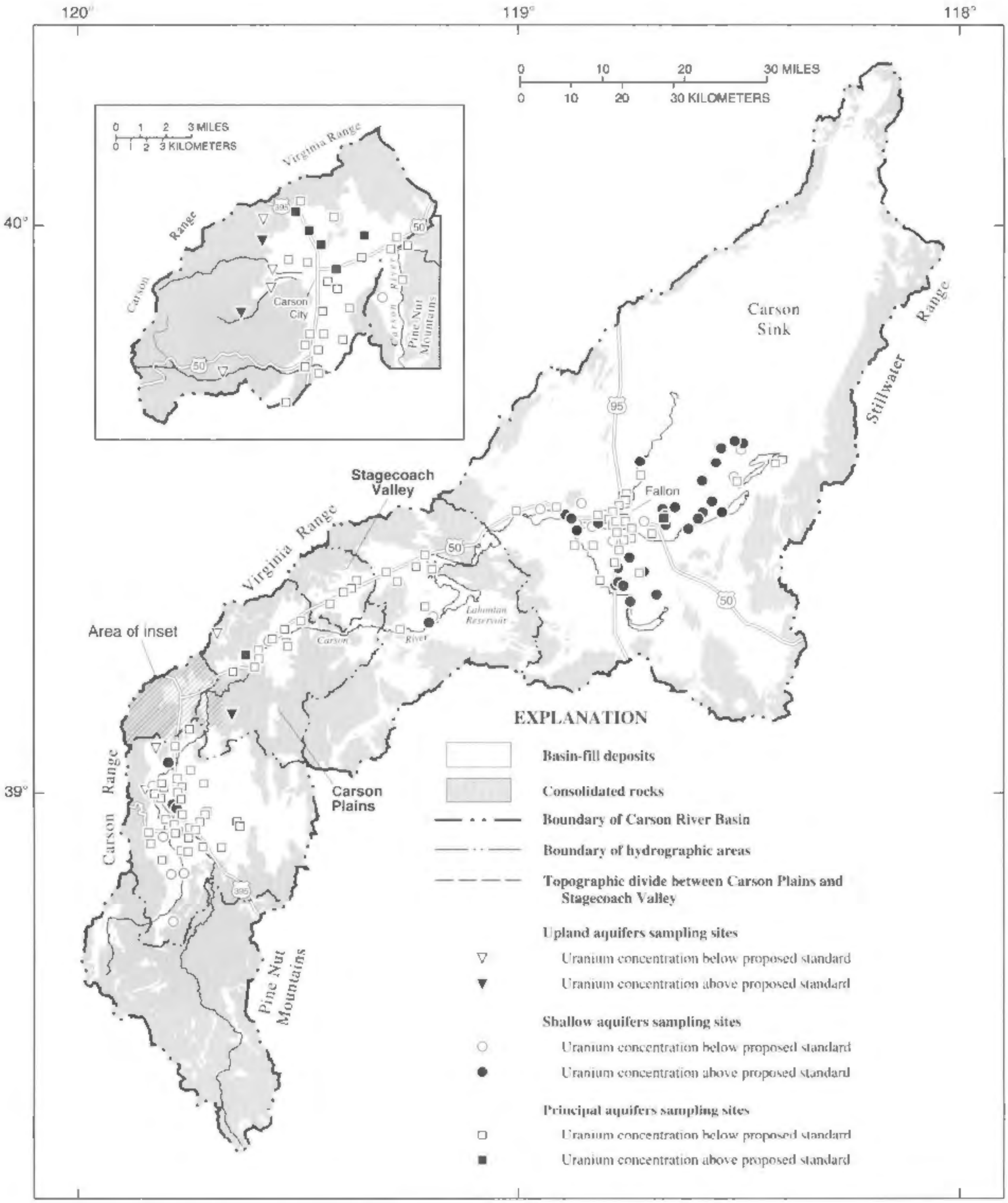


Figure 44. Summary statistics for selected radionuclides in principal aquifers in Carson River Basin, Nevada and California.



Base from U.S. Geological Survey digital data, 1:100,000, 1985
Local Mercator projection
Central meridian -119°10', latitude of true scale 39°20'

Geology modified from Johnson (1977), Stewart and others (1982), and Greene and others (1991)

Figure 45. Ground-water sampling sites in Carson River Basin, Nevada and California, where concentrations of uranium exceed proposed U.S. Environmental Protection Agency drinking-water standard (20 micrograms per liter).

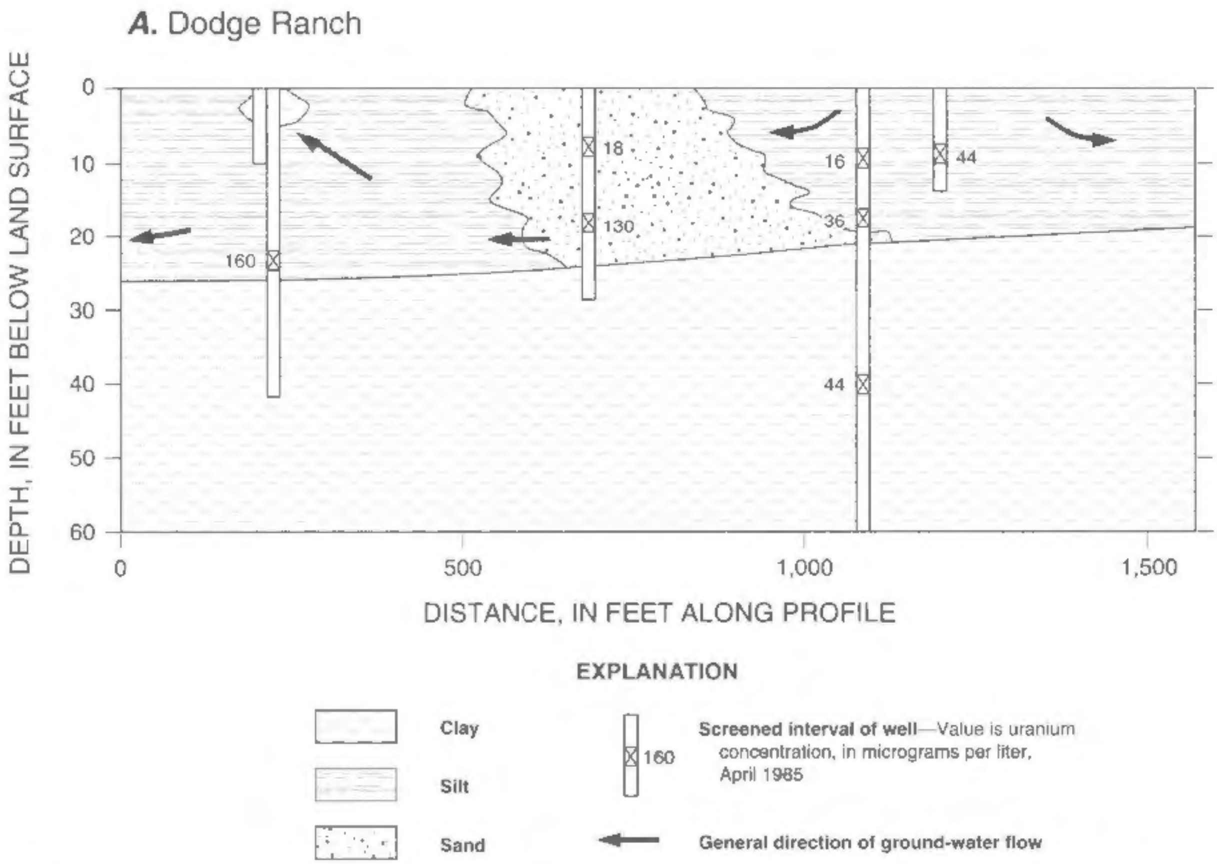


Figure 46. Uranium concentrations in shallow ground water at two sites in southern Carson Desert, Nevada. *A*, Dodge Ranch; and *B*, Lead Lake.

small areas throughout the study area. This water dissolves primary minerals containing uranium and uranium-rich metal-oxide coatings on mineral grains and in the rock matrix. Uranium concentrations in granitic rocks range from about 3 to 10 mg/kg (Otton and others, 1989, p. 25). Titanite (sphene) is the most significant contributor of uranium to the water because titanite is more abundant than zircon and is highly altered (fig. 48). Titanite is ubiquitous in granitic rock and because the titanite is highly altered, uranium is readily released to the ground water.

In ground water containing dissolved oxygen, uranium generally is present in the 6^{+} oxidation state as a uranyl ion. Uranyl complexes adsorb onto surfaces of aquifer materials, such as iron oxyhydroxide (Langmuir, 1978; Hsi and Langmuir, 1985; Kamineni, 1986), organic matter (Szalay, 1964; Nakashima and others, 1984; Leventhal and others, 1986), and clay minerals (Ames and others, 1983; Kamineni, 1986), and coprecipitate with iron and manganese oxides (Kamineni, 1986; Guthrie, 1989). Consequently, dissolved uranium is removed from water and is concentrated in iron- and manganese-oxide coatings in fractures and fine-grained sediments and on organic matter (fig. 49).

Fluvial processes transport sediments containing uranium from the upper to the lower Carson River Basin. Uranium concentrations are less than 9 mg/kg in 95 percent of 351 surficial sediment samples collected throughout most of the Carson River Basin (E.A. Frick, U.S. Geological Survey, written commun., 1992; based on data from Tidball and others, 1991). Uranium concentrations are highest in sediments adjacent to the Carson Range in Carson Valley. Riparian vegetation along the Carson River has periodically been incorporated into basin-fill sediments because of flooding. In addition, vegetation in stream channels along the east slope of the Sierra Nevada has been carried down channels and buried in alluvial fans along the west side of Carson Valley. Thus, organic matter is present in basin-fill sediment in the western part of the basin, predominantly along buried river channels and alluvial fan deposits. These relatively organic-rich sediments

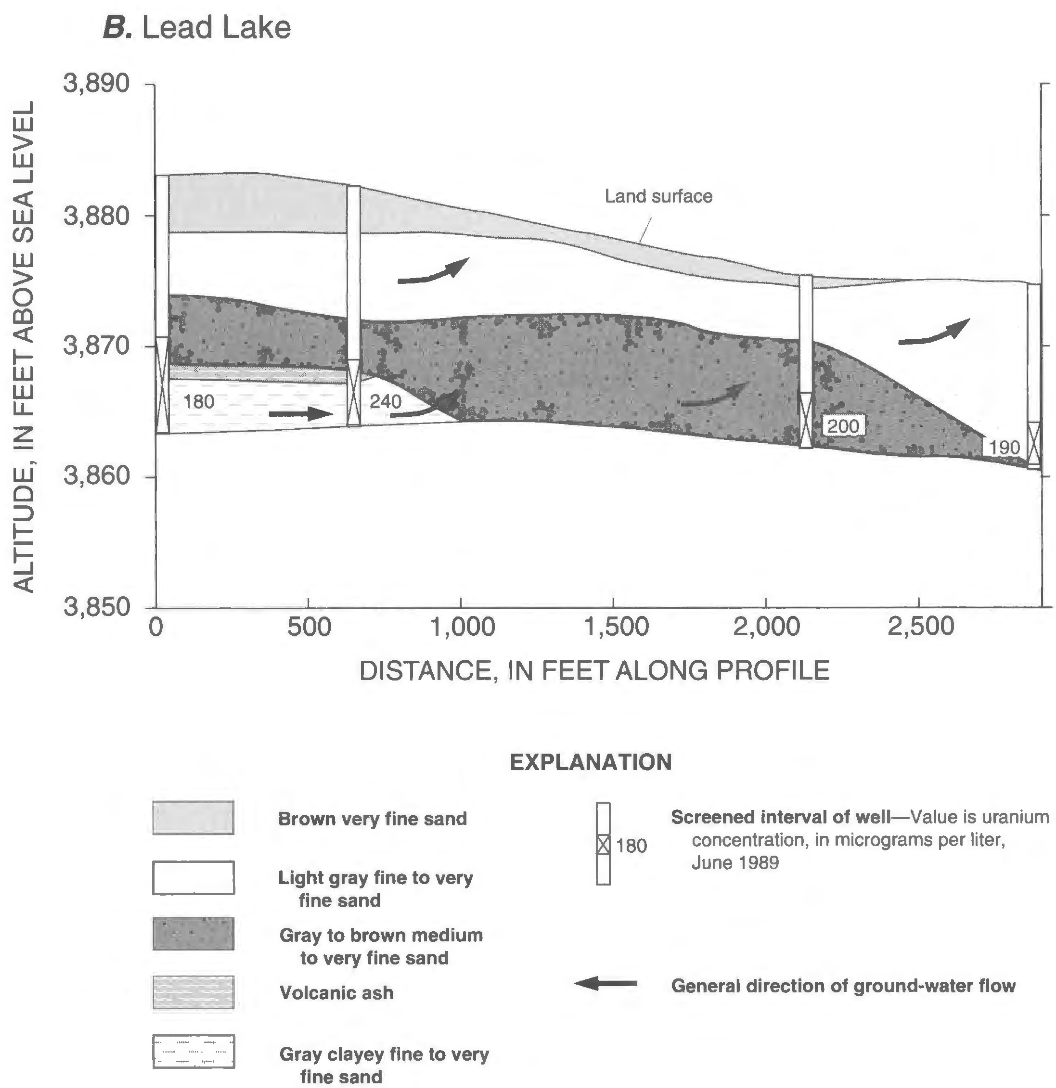
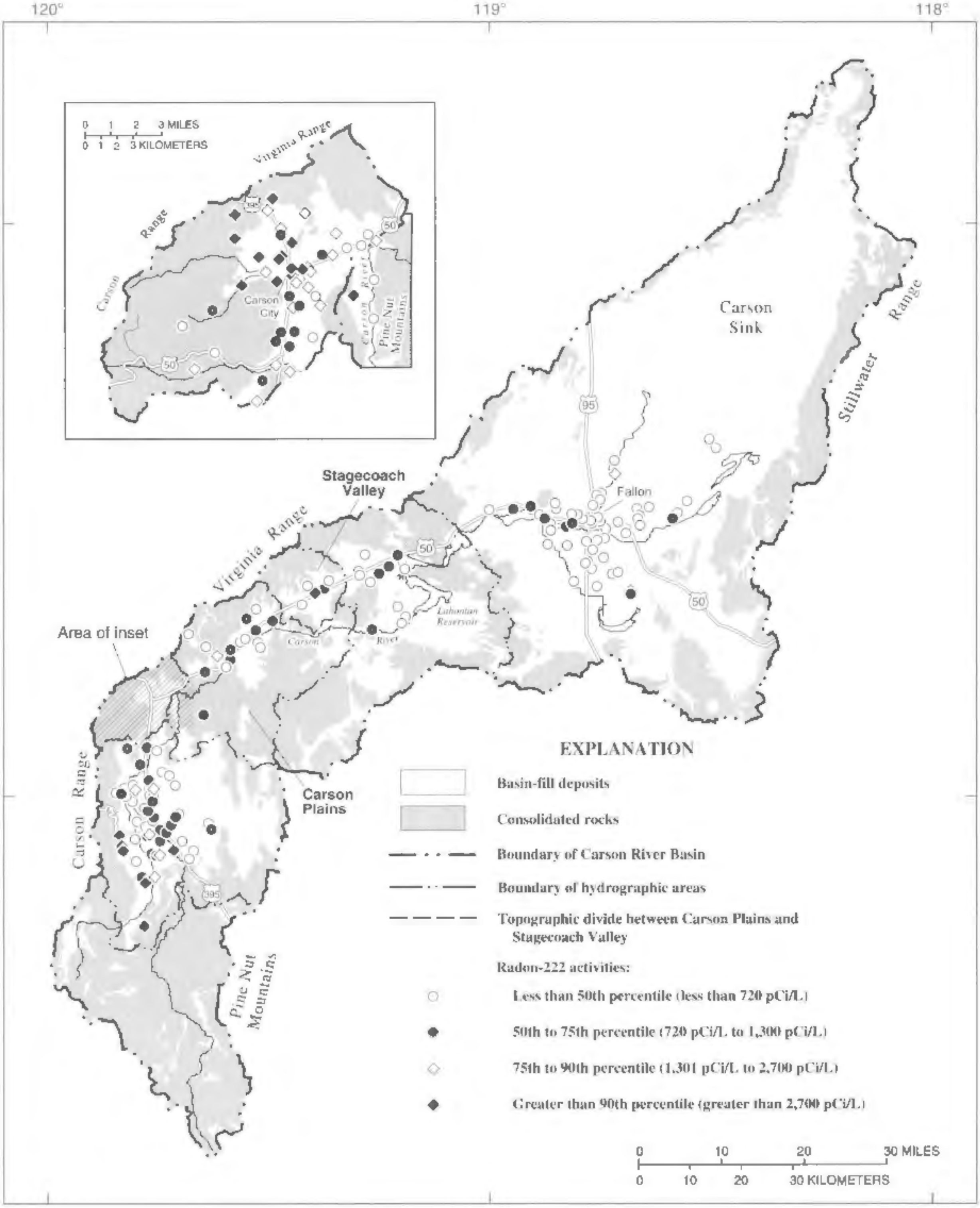


Figure 46. Continued.

contain uranium because organic matter strongly adsorbs uranium (Szalay, 1964; Nakashima and others, 1984; Leventhal and others, 1986).

Uranium can be released from organic matter and metal-oxide coatings through dissolution and desorption (Welch and Lico, 1988; Thomas and others, 1993). Uranium activities generally are less than 40 pCi/L in ground water of the Carson River Basin. Exceptions are shallow ground water in Carson Desert and a spring in the Pine Nut Mountains, where uranium activities are markedly greater. These locally high activities in the shallow ground water of Carson Desert are caused by irrigation water saturating previously dry sediments. Readily available uranium is released from hematite coatings and sedimentary organic matter by dissolution and desorption. Uranium in Carson Desert is concentrated in metal-oxide coatings on mineral grains and in sedimentary organic matter (fig. 50). Some shallow ground water has been affected by evapotranspiration, resulting in high uranium concentrations and dissolved-solids concentrations.

Radon-222 is the decay product of radium-226, but radon-222 activities measured in ground water are produced almost exclusively by radium-226 in aquifer material rather than from decay of dissolved radium-226. Highest measured radon-222 activities are in ground water from consolidated rock and unconsolidated deposits in and adjacent to the Sierra Nevada (fig. 47; Lico and Rowe, 1991). Fractures in consolidated rock along the range front allow ground water to flow



Base from U.S. Geological Survey digital data, 1:100,000, 1985
Local Mercator projection
Central meridian -119°10', latitude of true scale 39°20'

Geology modified from Johnson (1977), Stewart and others (1982), and Greene and others (1991)

Figure 47. Radon-222 activities in ground water of Carson River Basin, Nevada and California.

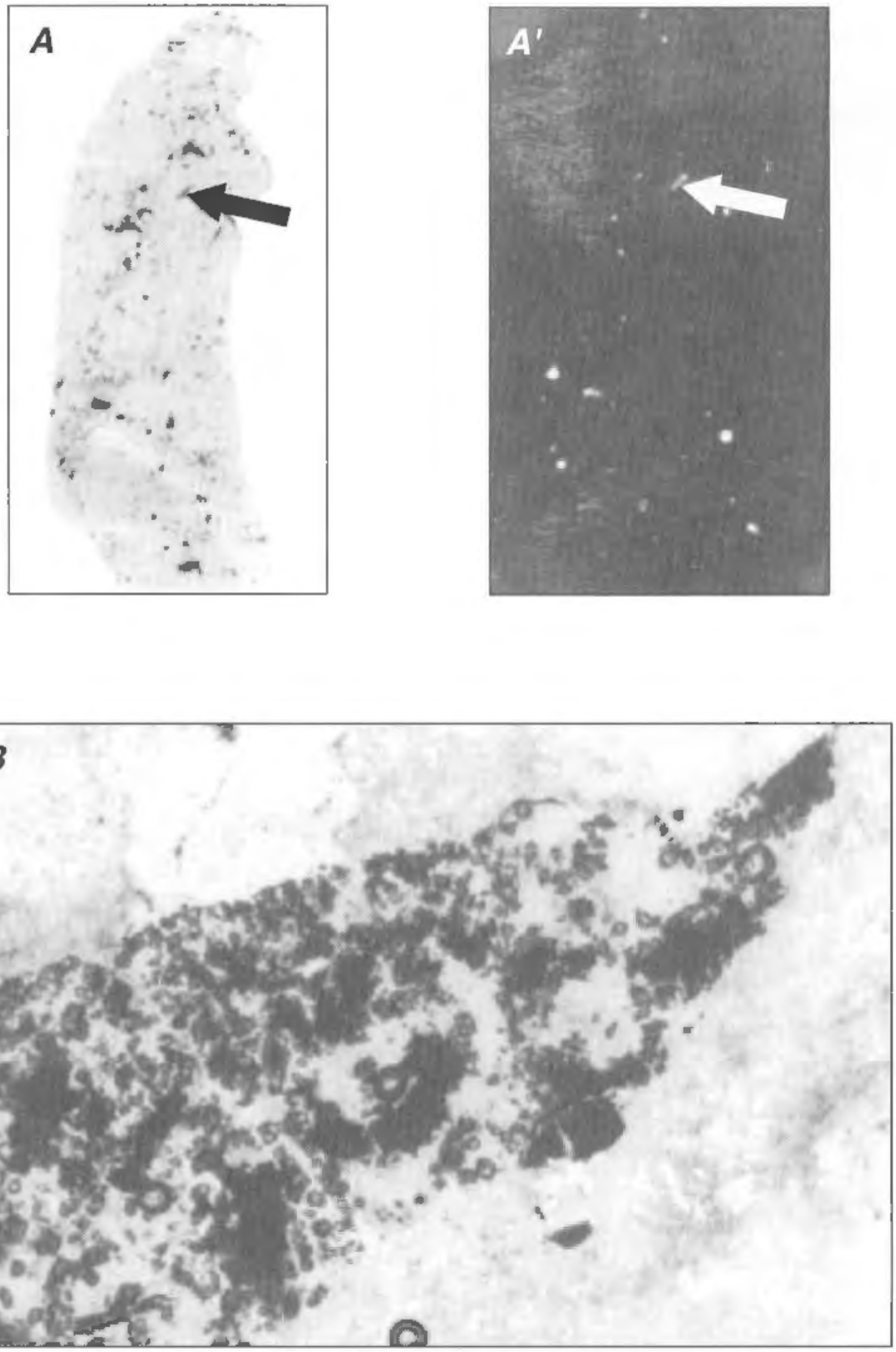


Figure 48. Radiation from shallow sediments of Carson River Basin, Nevada. *A*, Thin section (26 millimeters across) of weathered granite, and *A′*, Accompanying auto-radioluxograph exposed for 168 hours. Light areas on micrograph are produced by alpha radiation, primarily from naturally occurring uranium. Very bright circular spots on micrograph are due to emissions from zircons; more diffuse elongated light spots are from titanite. *B*, Plain light photomicrograph (2 millimeters across) showing titanite in highly altered crystal (shown by arrows in *A* and *A′*).

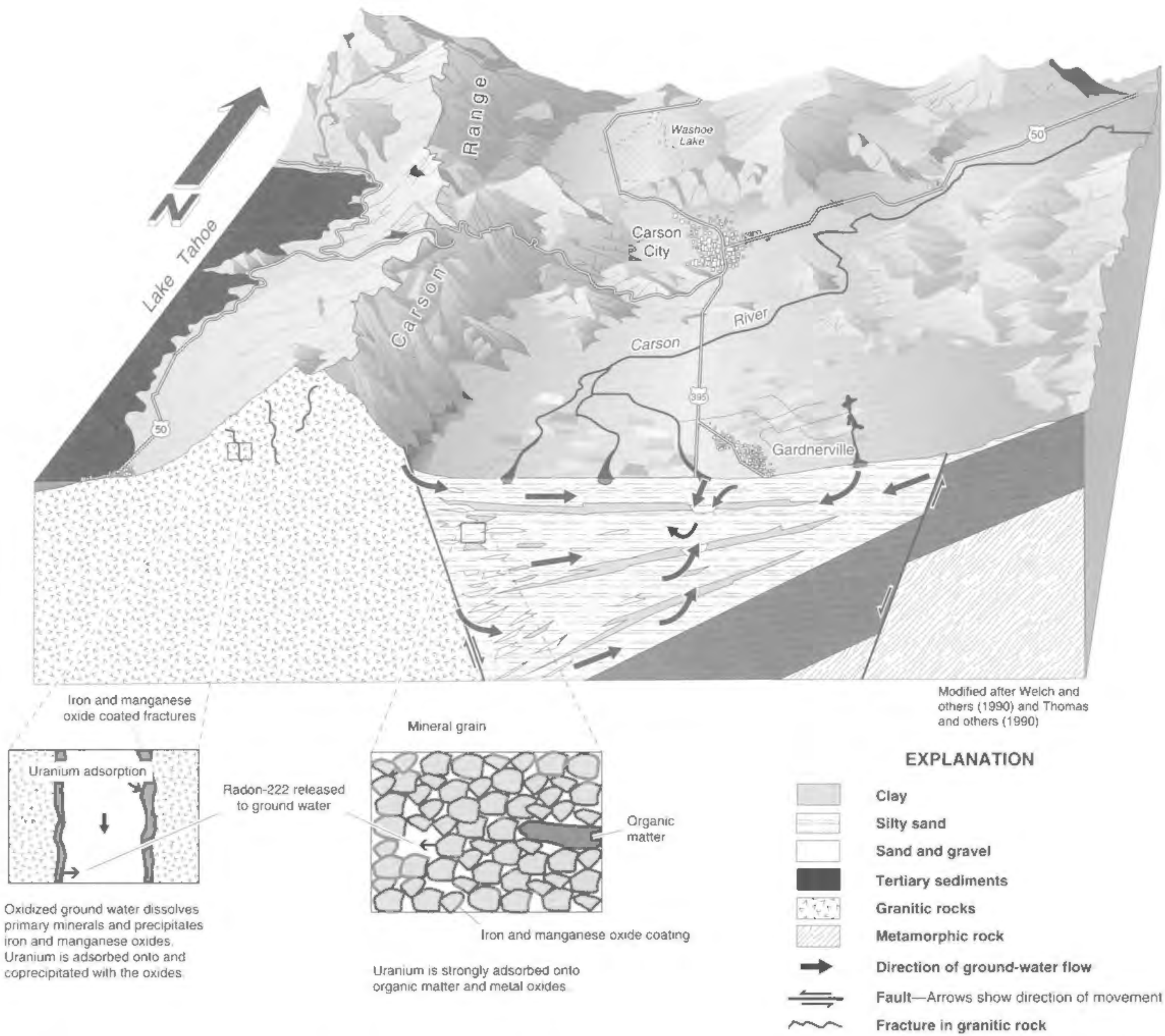


Figure 49. Schematic three-dimensional "block diagram" showing conceptual model of uranium in ground water of upper Carson River Basin, Nevada and California.

through mountain blocks and into basin-fill aquifers These fractures commonly have metal-oxide coatings that adsorb uranium and its progeny, including radium-226 Thus, ground water flowing through these fractures locally contains high radon-222 activities In addition, sediment samples collected in the western part of Carson Valley contain higher uranium concentrations than samples from other parts of the valley, so these sediments probably also contain high radium activities

Synthetic Organic Compounds

***By* Stephen J Lawrence**

Ground-water samples were analyzed for as many as 154 synthetic organic compounds (Whitney, 1994) Ground-water samples from the Carson City urban area were analyzed for all 154 compounds Shallow ground-water samples from agricultural areas were analyzed for volatile compounds, insecticides, and herbicides Samples from principal aquifers were analyzed only for volatile compounds (36 compounds)

Synthetic organic compounds detected in ground-water samples from the Carson River Basin may not represent actual ground-water conditions, particularly for volatile compounds, because of sample contamination Contamination may be caused by contact with organic compounds on sampling equipment Movement of organic compounds as vapor, such as in storage areas for paint or chemicals, can contaminate samples Well construction can introduce organic compounds into ground-water samples through the use of organic-based drilling fluids, polyvinyl chloride (PVC) well casing, or cement used to connect sections of PVC casing Vinyl chloride is a major ingredient in PVC cement and can be released from well casings Phthalate esters used in the manufacture of PVC pipe used for casing can be released unless the casing is cleaned with detergent

In this study, sampling protocols included procedures designed to allow evaluation of sample contamination or loss of compounds during collection or analysis Procedures included use of "equipment blanks" to identify organic compounds introduced by sampling equipment, use of "trip blanks" to detect contamination during shipping, storage, and field transport Addition of known amounts of an organic compound to the sample allows estimation of losses by volatilization or degradation of the compounds, or matrix interference

Results of these efforts suggest that airborne compounds may be a source of several volatile compounds detected during the study At many sampling sites, wells are enclosed in buildings used for storage of products containing many of the organic compounds detected during the study Although the role these storage practices have in contaminating samples during collection is not known, the presence of organic vapor in well houses is a likely source because the sample bottle must be opened to collect the sample, thereby allowing diffusion into the bottle and the water sample In addition, airborne transport may cause persistent, but barely detectable, amounts of 1, 2 and 1,1-dichloroethane in many ground-water samples collected during this study Airborne pathways are probable because trip blanks also were contaminated and other sources of dichloroethane have not been identified Airborne transport of gasoline vapors in sampling vehicles also may affect concentrations of benzene, toluene, xylene, and ethylbenzene detected in some samples

Analysis of equipment blanks did not indicate sampling equipment as a source of organic compounds measured during the study On the basis of data from spiked samples, loss of volatile compounds in samples prior to analysis could be as high as 10 to 20 percent of initial concentration, the loss is caused by volatilization and degradation Similarly, concentrations of many herbicides and insecticides could decrease by as much as 5 percent of their initial concentration due to degradation

For the chlorophenoxy acid herbicide Dicamba, concentrations were slightly above the laboratory reporting limit in shallow samples from Churchill Valley and Carson Desert However, shallow ground-water samples from Churchill Valley and especially from Carson Desert also contain high concentrations of dissolved organic carbon Naturally occurring dissolved organic carbon may falsely indicate low concentrations of Dicamba (Whitney, 1994) Because the reported Dicamba concentrations may be caused by interference, Dicamba is not considered further in this report

Only 23 organic compounds were detected in ground-water samples Tetrachloroethylene (PCE), trichloroethylene (TCE), prometone, and chloroform were the most frequently detected organic compounds in the Carson River Basin (table 17) Two samples contained TCE concentrations greater than the MCL (5 μg/L) for that compound Because of the low proportion of samples with detectable concentrations compared to the number of samples, quantitative or

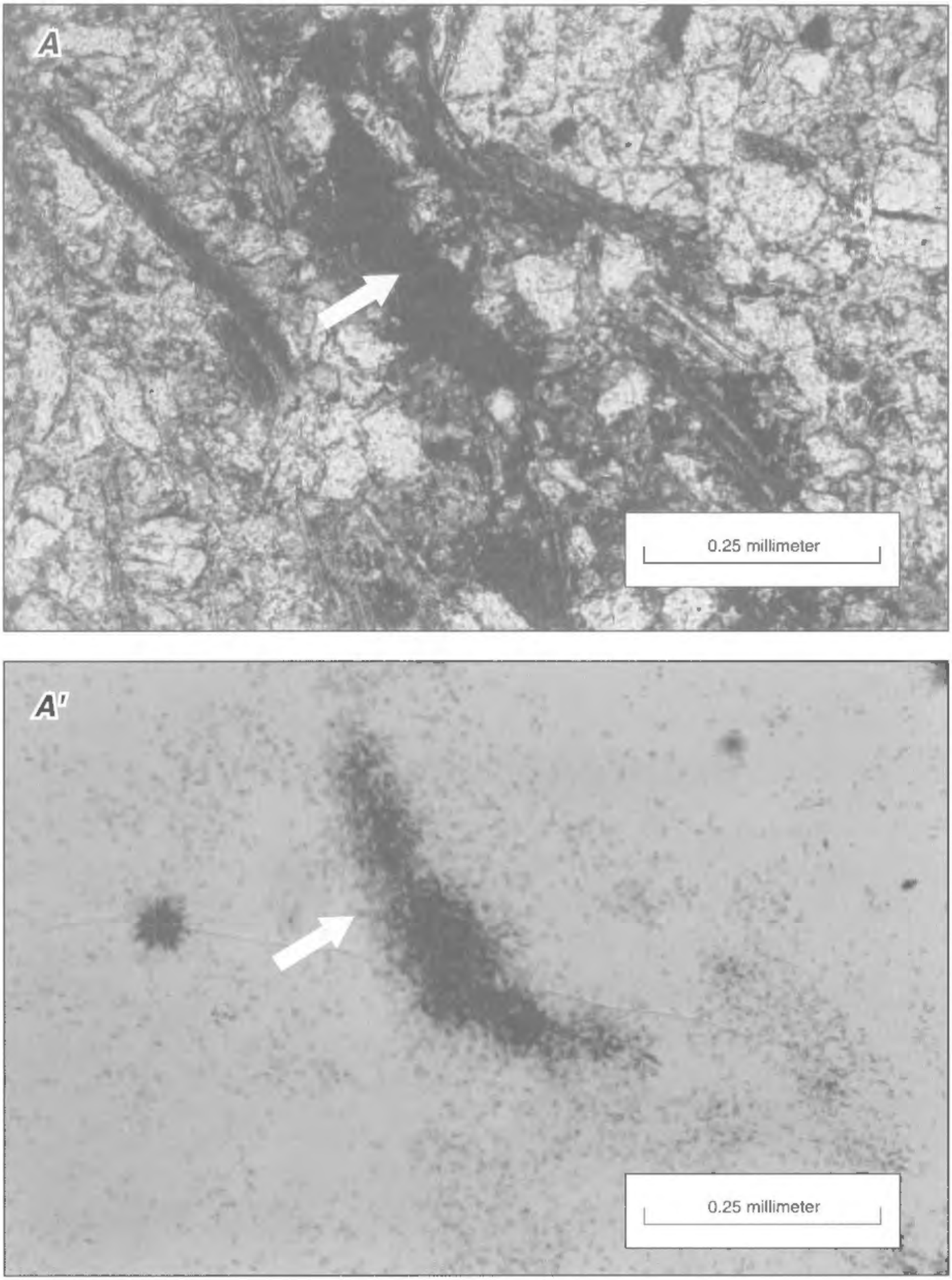


Figure 50. Fission tracks from shallow sediment of southern Carson Desert, Nevada. Tracks were produced by irradiation of sample with thermalized neutron flux. Photograph (1 millimeter across) at top of figure shows etched fission tracks that correspond to sediment sample shown below. Large area of concentrated fission tracks (shown by arrow) corresponds to metal oxides. Small areas of concentrated tracks are zircon or sphene. From Thomas and others (1993, fig. 9).

statistical comparisons between land uses and aquifers is not possible Therefore, only qualitative descriptions and comparisons are presented

Ground-water samples from Carson Valley contained PCE and TCE more commonly than any other synthetic organic compound These compounds were measured only in samples from shallow and principal aquifers (table 18) Two samples from upland aquifers contained chloroform Six samples from shallow aquifers in Carson Valley contained the herbicides 2,4-D and simazine, and the insecticides diazinon and ethion

The solvents PCE, TCE, 1,2-dichloroethylene (DCE), and 1,1,1- trichloroethane (TCA) were detected in samples of shallow ground water in Eagle Valley, primarily from the Carson City urban area (table 18) Also detected were the triazine herbicides cyanazine, prometone, and simazine The highest concentrations of PCE, TCE, DCE, chloroform, prometone, TCA, and cyanazine were found in samples from the Carson City urban area in Eagle Valley In the Dayton Valley and Churchill Valley hydrographic areas, only two synthetic organic compounds (PCE and TCA) were detected in ground-water samples These were in three samples collected from principal aquifers in Dayton Valley and one sample from a principal aquifer in Churchill Valley Shallow aquifers in Carson Desert yielded samples containing four synthetic organic compounds, three of which were herbicides or insecticides (table 18)

Samples collected from wells in shallow aquifers in urban and agricultural settings show some differences in the synthetic organic compounds most frequently detected Chloroform, prometone, PCE, TCE, and DCE were detected more frequently and at higher concentrations in samples from the urban area than in samples from agricultural areas

Table 17 Summary of synthetic organic compounds detected in ground water of Carson River Basin, Nevada and California, 1987-90

[Abbreviations µg/L, micrograms per liter, MCL, maximum contaminant level, --, MCL not established]

Constituent	Laboratory reporting limit (µg/L)	MCL (µg/L)	Number of samples	Number of samples exceeding		Maximum concentration (µg/L)
				Reporting limit	MCL	
Constituents with primary drinking-water standards						
Benzene	0 2	5	225	3	0	1 9
1,2-Dichloroethane	2	5	173	3	0	1
Vinyl chloride	2	2	229	2	1	5
1,1,1-Trichloroethane (TCA)	2	200	229	2	0	4
Trichloroethylene (TCE)	2	5	229	15	2	20
Constituents without drinking-water standards						
Bis (2-ethylhexyl) phthalate	5	--	65	1	0	13
Chloroform	2	--	229	9	0	1 7
Chloroethane	2	--	229	1	0	3 5
Chloromethane	2	--	229	1	0	2 5
Dichlorodifluoromethane	2	--	227	2	0	2
1,1-Dichloroethane	2	--	225	2	0	10
1,2-Dichloroethylene (DCE)	2	--	125	3	0	6 8
Ethylbenzene	2	--	226	2	0	5
Tetrachloroethylene (PCE)	2	--	228	16	0	44
Toluene	2	--	208	3	0	3
Xylene	2	--	221	2	0	1 5
2,4-D	01	--	85	2	0	07
Silvex	01	--	85	1	0	01
Diazinon	01	--	31	1	0	01
Ethion	01	--	31	1	0	02
Prometone	1	--	85	9	0	3 8
Simazine	1	--	85	4	0	2
Cyanazine	1	--	85	1	0	1

Table 18. Summary of synthetic organic compounds detected in ground water in the different aquifer systems of Carson River Basin, Nevada and California, by hydrographic area, 1987-90

[Abbreviation and symbol µg/L, micrograms per liter, --, concentration not determined or below laboratory reporting limit]

Constituent	Upland aquifers			Shallow aquifers			Principal aquifers		
	Number of samples	Number of samples exceeding reporting limit	Maximum concentration (µg/L)	Number of samples	Number of samples exceeding reporting limit	Maximum concentration (µg/L)	Number of samples	Number of samples exceeding reporting limit	Maximum concentration (µg/L)
Carson Valley									
Benzene	6	0	--	10	2	1 9	35	1	0 2
Chloroform	6	2	0 2	11	0	--	35	1	2
Chloroethane	6	0	--	11	1	3 5	35	0	--
Chloromethane	6	0	--	11	0	--	35	0	--
2,4-D	1	0	--	14	1	04	0	--	--
Diazinon	0	--	--	1	1	01	0	--	--
Dichlorodifluoro-methane	6	0	--	10	0	--	35	0	--
1,1-Dichloroethane	6	0	--	11	1	10	35	1	2
Ethion	0	--	--	1	1	02	0	--	--
Ethylbenzene	6	0	--	10	1	5	35	1	2
Simazine	1	0	--	14	2	2	0	--	--
Tetrachloroethylene (PCE)	6	0	--	11	0	--	35	4	9 8
Toluene	5	0	--	8	2	3	33	0	--
Trichloroethylene (TCE)	6	0	--	11	1	4 6	35	1	9
Vinyl chloride	6	0	--	11	2	5 0	35	0	--
Xylene	6	0	--	10	1	1 5	35	1	2
Eagle Valley									
Chloroform	4	0	--	57	4	1 5	25	0	--
Cyanazine	0	--	--	31	1	1	0	--	--
1,2-Dichloroethylene (DCE)	0	--	--	56	5	6 8	0	--	--
Prometone	0	--	--	31	9	3 8	0	--	--
Simazine	0	--	--	31	1	1	0	--	--
Tetrachloroethylene (PCE)	4	0	--	55	8	44	25	0	--
1,1,1-Trichloroethane (TCA)	4	0	--	57	1	4	25	0	--
Trichloroethylene (TCE)	4	0	--	57	15	20	25	0	--
Dayton and Churchill Valleys									
Tetrachloroethylene (PCE)	0	--	--	0	--	--	26	3	5
1,1,1-Trichloroethane (TCA)	0	--	--	0	--	--	26	1	3
Carson Desert									
2,4-D	0	--	--	30	1	07	0	--	--
1,2-Dichloroethane	0	--	--	16	1	1 0	0	--	--
Silvex	0	--	--	31	1	01	0	--	--
Simazine	0	--	--	29	1	1	0	--	--

Sources of synthetic organic compounds detected in ground water within the Carson River Basin are varied For example, PCE, TCE, DCE, and TCA are found in general purpose degreasing products used for a variety of tasks that range from cleaning automobile engines to treating septic systems PCE, TCE, and DCE may move into shallow ground water by leaching from septic systems (Cantor and Knox, 1986, p 82), improper disposal of used solvents, or from leaks and spills TCE and DCE also can be produced by biologically mediated degradation of PCE under anaerobic conditions (Vogel and others, 1987, p 730-734) Chloroform detected within the Carson River Basin probably is from chlorinated municipal water recharging shallow ground water Chloroethane and 1,1-dichloroethane may be degradation products of TCA

Herbicides generally are much more soluble and leachable than insecticides Accordingly, herbicides tend to be detected in ground water more commonly (Smith and others, 1988, p 43) Low affinities of herbicides for organic matter mean that they do not readily partition into soil or sediment Individual herbicides may be present in ground water in widely variable concentrations because of variable application rates, degradation rates, soil properties, and irrigation practices The herbicides prometone, simazine, cyanazine, and 2, 4-D generally do not persist in a given matrix beyond about 90 days, except in areas where the application rates of these compounds are particularly high (Helling and others, 1988, p 176, Smith and others, 1988, p 40-43) An exception is Silvex, which is less soluble, has a greater affinity for organic matter, and is more persistent in the environment than either the triazine herbicides, or 2, 4-D (Mullison, 1987, p 121-126, Verschueren, 1988, p 1143)

Insecticides such as diazinon and ethion generally persist for longer periods than herbicides and have a higher affinity for soil organic matter (Smith and others, 1988, p 37-39) Thus, detection of herbicides (except for Silvex) in ground water would be most likely within 2 or 3 months following application In contrast, diazinon and ethion could be detected throughout the year, but probably at lower concentrations than herbicides, because the insecticides are less attenuated by soil organic matter The presence of diazinon, prometone, cyanazine, simazine, 2, 4-D, Silvex, and ethion in ground water probably is caused by infiltration from irrigated landscape and (or) vegetation or weed control in ditches within urban areas, and infiltration from irrigated agricultural land

Summary of Ground-Water Quality with Respect to Federal Drinking-Water Standards

***By* Alan H. Welch**

The ground-water quality in the Carson River Basin varies considerably, both areally and among the different aquifers This variability is reflected in the frequency with which drinking-water standards established and proposed by U S Environmental Protection Agency are exceeded Inorganic constituents that most commonly exceed drinking-water standards are, in general decreasing order of frequency, manganese, arsenic, nitrate, iron, and fluoride Chloride, sulfate, and dissolved-solids concentrations also exceed the standard in some places Measured uranium and, particularly, radon-222 commonly exceed proposed Federal standards

Constituents that most typically exceed established maximum contaminant levels (MCL's) in principal and shallow aquifers are arsenic, fluoride, and nitrate (fig 51) Among these, arsenic is the most common in the Carson River Basin Nearly all arsenic concentrations that exceed the 50 µg/L MCL are in Carson Desert, the topographically lowest part of the basin In water from principal aquifers, arsenic concentrations exceed the MCL more commonly in Carson Desert than in the upper and middle Carson River Basin (table 19) In water from shallow aquifers of Carson and Eagle Valleys, arsenic concentrations more commonly exceed the MCL than in water from principal aquifers (table 19) In contrast, the frequency of exceedance for arsenic in water from shallow and principal aquifers of Carson Desert is not significantly different (table 20) Within Carson Desert, water from nearly one-half of the wells tapping principal and shallow aquifers have arsenic concentrations greater than the Federal drinking-water standard Included in the principal aquifer is the basalt aquifer, which provides the sole source of supply for Fallon and the Fallon Naval Air Station

Fluoride concentrations in some water from shallow aquifers exceed the MCL in Carson Desert and in Carson and Eagle Valleys (fig 51) In contrast, fluoride concentrations in water from principal aquifers exceed the 4 mg/L MCL only in Carson Desert

Nitrate concentrations in water from shallow and intermediate and basalt aquifers exceed the MCL (10 mg/L as nitrogen) in the Carson and Eagle Valleys and Carson Desert (fig 51) Higher nitrate values in

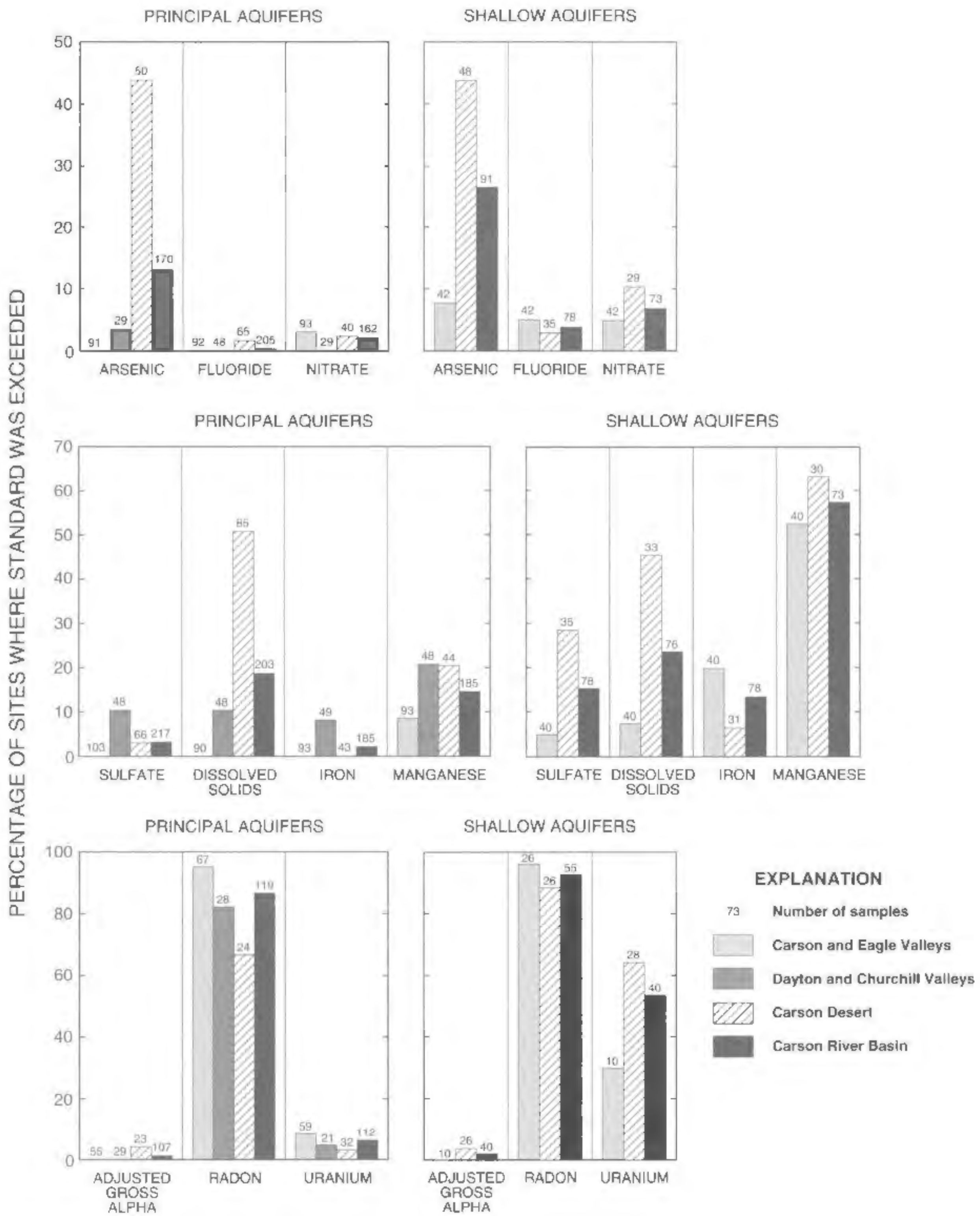


Figure 51. Percentage of ground-water sampling sites in Carson River Basin, Nevada and California, where selected inorganic constituents and radionuclides exceeded existing and proposed U.S. Environmental Protection Agency drinking-water standards.

Table 19 Statistical comparison of the frequency with which selected inorganic constituents exceed drinking-water standards in ground water from upper, middle, and lower Carson River Basin, Nevada and California

[All constituents, except for constituent in **bold**, have higher frequencies of exceedance in lower basin, p-values determined by chi-square test (Conover, 1980, p 145) Symbol --, no constituent]

Area	Highly significant (p less than 0 01)	Significant (p greater than 0 01 and less than or equal to 0 05)	Not significant (p greater than 0 05)
		Principal aquifers	
Carson and Eagle Valleys compared with Carson Desert	Sulfate, dissolved solids	Iron, manganese	Arsenic, nitrate, fluoride, radon, uranium
Dayton and Churchill Valleys compared with Carson Desert	Arsenic, dissolved solids	--	Fluoride, nitrate, sulfate, iron, manganese, uranium
Carson and Eagle Valleys compared with Carson Desert	Arsenic, fluoride, dissolved solids, **radon**	Manganese	Nitrate, sulfate, iron, uranium
		Shallow aquifers	
Carson and Eagle Valleys compared with Carson Desert	Arsenic, sulfate, dissolved solids	--	Nitrate, fluoride, iron, manganese, radon, uranium

principal aquifers of Carson and Eagle Valleys generally are in areas where septic tanks are used for domestic sewage disposal

The secondary maximum contaminant levels (SMCL's) for sulfate (500 mg/L), dissolved solids (1,000 mg/L), iron (0 6 mg/L), and manganese (0 1 mg/L) generally are exceeded more commonly in water from shallow aquifers than from principal aquifers Sulfate and dissolved-solids concentrations generally are higher in ground water in the middle and lower Carson River Basin because of evapotranspiration and dissolution of evaporite minerals, including gypsum Manganese concentrations commonly exceed the SMCL in water from shallow aquifers in both the upper and lower basin Exceedances of the manganese SMCL are less common in principal aquifers and are less common in the upper basin than elsewhere Iron exceedances are much less common than manganese throughout the basin in both shallow and principal aquifers The iron exceedances are more common in ground water from the Carson and Eagle Valleys area than from Carson Desert

The overall ground-water quality can be expressed in terms of the percentage of ground-water samples that contain one or more constituents that exceed a proposed or current drinking-water standard (fig 52) The percentages for the MCL exceedances were calculated using only samples that have been analyzed for all inorganic constituents that have an established MCL Similarly, the MCL plus SMCL percent-ages were calculated using only samples that had been analyzed for all inorganic constituents that have an established MCL or SMCL The location of these sites is shown in figures 53 and 54 The percentages labeled maximum contaminant level, adjusted gross alpha, or uranium in figure 51 are based on samples with inorganic constituents and an established MCL plus analyses of uranium and gross-alpha activity

Ground water in principal aquifers of Carson Desert most commonly contains constituents that exceed a MCL (fig 52*A*) The principal aquifers of the upper and middle basin contain ground water that generally meets the MCL's—but less commonly meets both the MCL's and SMCL's Some ground water in Carson Desert that does not meet the MCL's is from the basalt aquifer beneath Fallon (fig 53) Water with constituents exceeding either an MCL or a SMCL is present throughout much of the basin (fig 54) If the proposed standards for uranium and adjusted gross alpha are adopted, ground water in the upper and middle parts of the basin would more commonly exceed a standard (fig 52*A*) Nearly all ground water in principal aquifers of the Carson River Basin contains more radon-222 than the proposed 300 pCi/L Federal standard

Shallow aquifers sampled beneath much of the upper and lower basin commonly contain ground water that does not meet at least one established MCL or SMCL (figs 52*B* and 54) Half the samples of shallow ground water in the upper basin fail to meet at least one MCL or SMCL In Carson Desert, 80 percent of shallow ground-water samples contained at least one

Table 20 Statistical comparison of the frequency with which selected inorganic constituents exceed drinking-water standards in water from principal and shallow aquifers of Carson River Basin, Nevada and California

[All constituents have higher frequencies of exceedance in shallow aquifers, p-values determined by chi-square analysis (Conover, 1980, p 144-147) Abbreviation (s), secondary standard for fluoride Symbol --, no constituent]

Area	Highly significant (p less than 0 01)	Significant (p greater than 0 01 and less than or equal to 0 05)	Not significant (p greater than 0 05)
	Principal compared with shallow aquifers		
Carson and Eagle Valleys	Iron, manganese	Arsenic, fluoride(s), dissolved solids	Nitrate, sulfate, radon, uranium
Carson Desert	Manganese, sulfate, uranium	--	Arsenic, nitrate, fluoride(s), radon, dissolved solids, iron

constituent that exceeds a drinking-water standard If the proposed standards for uranium and adjusted gross alpha are adopted, then ground water in the upper basin would exceed a MCL in about 40 percent of the samples—compared to about 15 percent on the basis of current MCL's (fig 52*B*) In Carson Desert, the adoption of standards for these two radionuclides would increase the frequency of exceedance from about 45 to more than 70 percent Nearly all ground water in shallow aquifers in the Carson River Basin has radon-222 activities that exceed the proposed 300 pCi/L standard

SUMMARY

The Carson River Basin is an area of dramatic contrasts The Carson River drains pristine wilderness of the forested Sierra Nevada, which provides much of the basin's water The chemical composition of the Carson River changes from that of a fresh, untamed whitewater river in the Headwaters Area to that of stagnant, saline sloughs and alkali lakes in Carson Desert The ground-water quality, particularly in shallow aquifers, broadly mirrors the chemical changes in the river—a major source of recharge to basin-fill aquifers Contrasts in ground-water quality within the Carson River Basin are evident across the basin, among the different aquifers, and, to a lesser extent, between shallow ground water beneath urban land and agricultural land

Although precipitation in excess of 25 in/yr can fall in the uplands, low areas that make up most of the basin typically receive 3 to 11 in/yr Precipitation decreases with increasing distance from the Sierra Nevada, which is the wettest part of the basin

Agriculture remains and important land use, but rapid increases in population have led to increased urban-land use Wildlife management areas, particularly in Carson Desert, represent another important land use Traditionally, most ground water has been used for irrigation The burgeoning population has led to increased use of ground water for domestic purposes In 1988, domestic use was nearly equal to the amount used for agricultural irrigation Total ground-water use more than tripled from 1969 to 1988

Most ground water in the Carson River Basin is withdrawn from basin-fill sediments These sediments partly fill structural basins formed by extensional faulting The faulting also raised the consolidated rocks that form the mountainous uplands The basin-fill deposits, which reach thicknesses of 10,000 feet or more, locally include volcanic rocks In the Carson Desert, volcanic rocks are an important source of supply for the City of Fallon and the Fallon Naval Air Station

Using current drinking-water standards as a measure of overall water quality, ground-water quality in principal aquifers in the upper basin generally is good Principal aquifers in the upper basin are a major source of supply for municipal systems that provide water to the communities of Minden, Gardnerville, and Carson City Precipitation falling on the Sierra Nevada infiltrates and reacts with igneous and metamorphic rocks This water, along with recharge from the Carson River in areas of heavy ground-water pumping, is the major source of recharge to principal aquifers Except for locally high concentrations of nitrate and presence of synthetic organic compounds, ground-water quality in principal aquifers generally results from chemical reactions with aquifer materials Locally, ground water with little or no dissolved oxygen contains manganese concentrations greater than the drinking-water standard Some ground water in and adjacent to the Sierra Nevada contains uranium concentrations greater than the proposed drinking-water standard Radon activities in the Sierra Nevada locally exceed 10,000 pCi/L and are highest in the Carson Basin

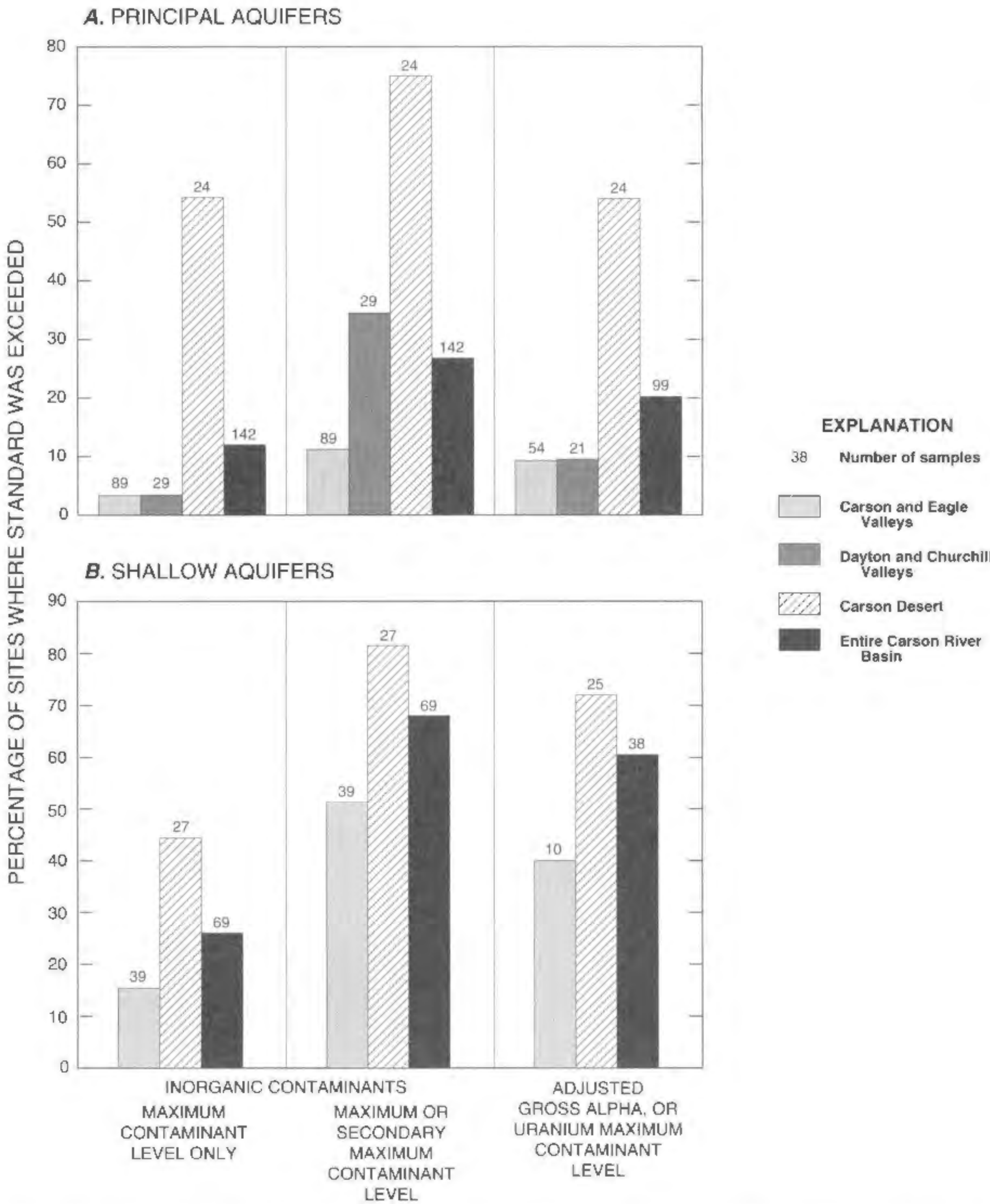
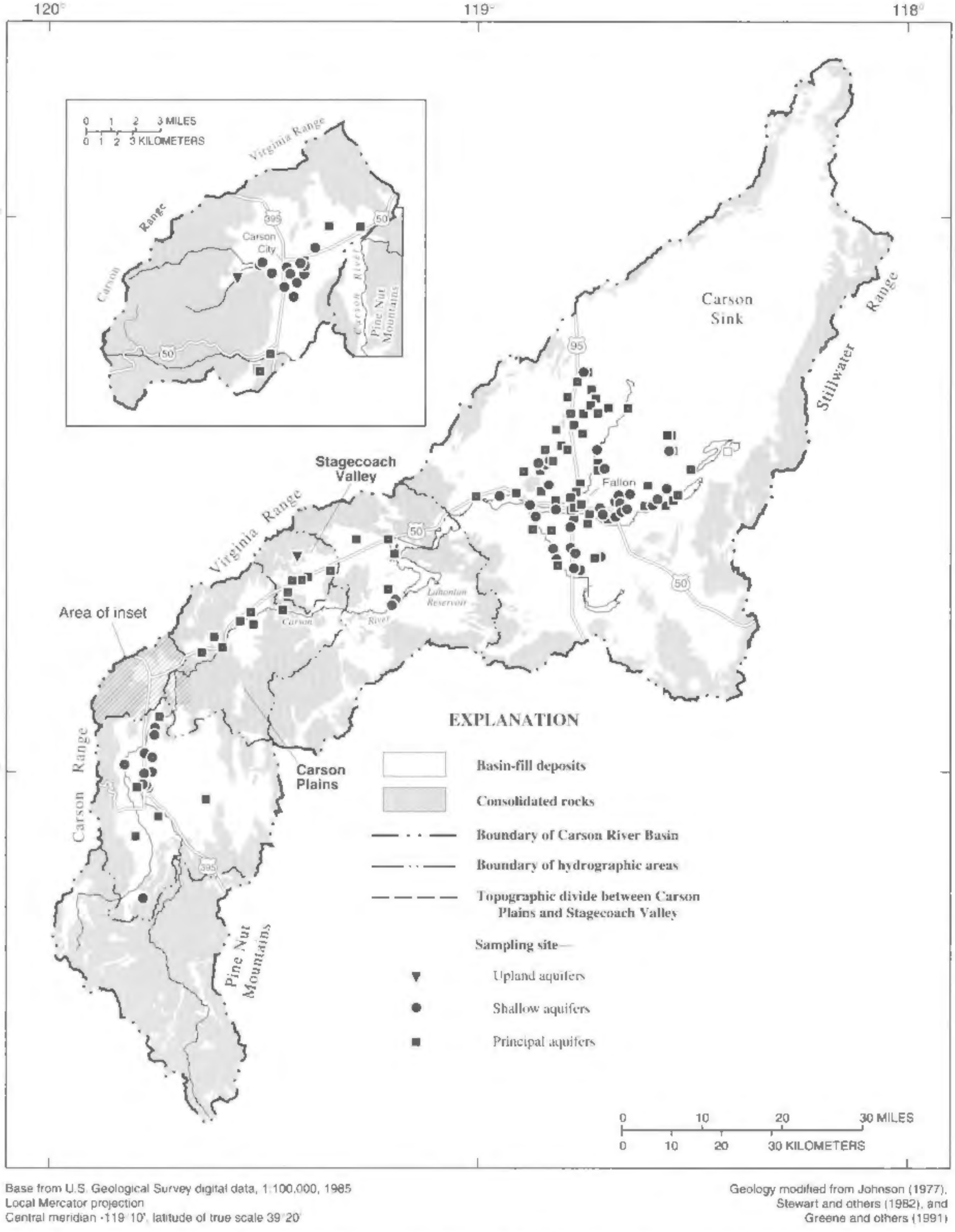


Figure 52. Summary of percentage of ground-water sampling sites in Carson River Basin, Nevada and California, where selected inorganic constituents and radionuclides exceeded existing and proposed U.S. Environmental Protection Agency drinking-water standards.



Base from U.S. Geological Survey digital data, 1:100,000, 1985
Local Mercator projection
Central meridian -119°10', latitude of true scale 39°20'

Geology modified from Johnson (1977), Stewart and others (1982), and Greene and others (1991)

Figure 53. Ground-water sampling sites in Carson River Basin, Nevada and California, where inorganic constituents exceed Nevada State primary maximum contaminant levels. Only sites with analyses for all inorganic constituents with primary maximum contaminant levels were considered.

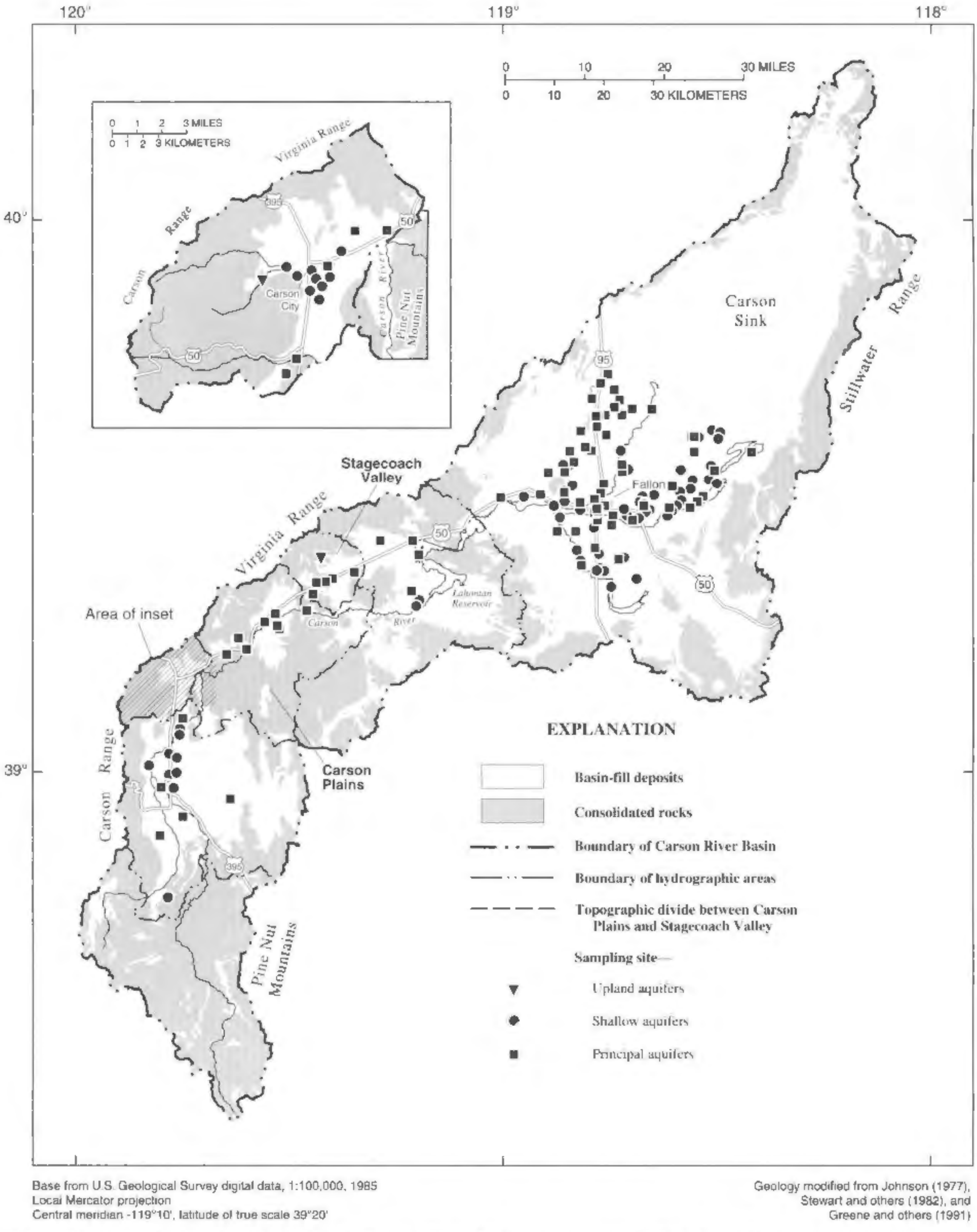


Figure 54. Ground-water sampling sites in Carson River Basin, Nevada and California, where inorganic constituents exceed Nevada State primary or secondary maximum contaminant levels. Only sites with analyses for all inorganic constituents with primary and secondary maximum contaminant levels were considered.

Shallow aquifers in Carson Valley are recharged primarily by water diverted from the Carson River, in Eagle Valley, the shallow recharge is principally from watering of lawns and other landscape vegetation Water in these aquifers contains higher concentrations of most major constituents and, compared to water in principal aquifers, more commonly contains concentrations of some minor constituents that exceed drinking-water standards Manganese exceeds the SMCL at more than 25 percent of the sampled sites Minor constituents that exceed drinking-water standards at less than 10 percent of sampled sites are arsenic, fluoride, nitrate, and iron Water from shallow aquifers more commonly contains concentrations of arsenic, fluoride, iron, and manganese in excess of the drinking-water standards than does water from the principal aquifers

Shallow aquifers beneath the upper basin locally contain herbicides, pesticides, and volatile organic compounds Beneath the urban part of Carson City, prometone, trichloroethylene, and tetrachloroethylene were found at concentrations well above the laboratory minimum reporting level Trichloroethylene was found at concentrations above the drinking-water standard With a few exceptions, ground water beneath agricultural land in Carson Valley contained, at most, low concentrations of synthetic organic compounds

Principal aquifers beneath the sparsely populated middle Carson River Basin are recharged by precipitation falling on the uplands and, locally, by the Carson River Concentrations of major constituents in water from principal aquifers in the lower basin generally are higher than in water from the principal aquifers of the upper basin Concentrations of dissolved solids, iron, manganese, and sulfate more commonly exceed drinking-water standards in principal aquifers of the middle than the upper basin

Carson Desert, at the distal end of the Carson River Basin, is a closed basin that loses water only by evapotranspiration Analyses of ground water indicate a wide range in concentrations of major and minor inorganic constituents, with dissolved solids reaching maximum concentrations greater than seawater Concentrations of sodium, chloride, bicarbonate, and dissolved solids generally are higher in shallow and principal aquifers of Carson Desert than in the upper and middle parts of the basin Minor-constituent concentrations, including those for arsenic, boron, fluoride, lithium, and molybdenum, also are higher in both shallow and principal aquifers in the Carson Desert compared with the other two parts of the basin Water in principal aquifers beneath Carson Desert generally contains lower concentrations of calcium, magnesium, bicarbonate, sulfate, lithium, manganese, molybdenum, and nitrate than water in shallow aquifers More than 10 percent of sampled ground water from both shallow and principal aquifers contains concentrations of arsenic, dissolved solids, and manganese greater than the drinking-water standards

Several minor constituents reach unusually high concentrations in shallow aquifers of Carson Desert Notable are arsenic, iron, manganese, and uranium Among these four elements, all except uranium reach concentrations greater than 1 mg/L Processes leading to the high concentrations include evapotranspiration and reactions of sedimentary organic matter with metal oxides Locally, these reactions appear to be an indirect result of a rise in the water table in response to application of irrigation water for agricultural activities

REFERENCES CITED

Ames, L L , McGarrah, J E , and Walker, B A , 1983, Sorption of trace constituents from aqueous solutions onto secondary minerals—II Radium Clays and Clay Minerals, v 31, p 335-342

Arteaga, F E , 1982, Mathematical model analysis of the Eagle Valley ground-water basin, west-central Nevada U S Geological Survey Open-File Report 80-1224, 55 p

Arteaga, F E , and Durbin, T J , 1978, Development of a relation for steady-state pumping rate for Eagle Valley ground-water basin, Nevada U S Geological Survey Open-File Report 79-261, 44 p

Ball, J W , Nordstrom, D K , and Zachman, D W , 1987, WATEQ4F—A personal computer FORTRAN translation of the geochemical model WATEQ2 with revised data base U S Geological Survey Open-File Report 87-50, 108 p

Bingler, E C , 1977, Geologic map of the New Empire quadrangle Nevada Bureau of Mines and Geology Map 59, scale 1 24,000

Bostic, Robert, Hitch, Dan, Van Gordon, Lloyd, and Swanson, Robert, 1991, Water resources data, Nevada, water year 1990 U S Geological Survey Water-Data Report NV-90-1, 358 p

Bowser, C A , and Hatcher, J T , 1967, Adsorption of fluoride by soils and minerals Soil Science, v 103, p 141-154

Bureau of Reclamation, 1987a, Final environmental impact statement for the Newlands Project proposed operating criteria and procedures Washington, D C , 332 p

———1987b, Fallon Indian Reservation water quality report Sacramento, Calif , Bureau of Reclamation, Mid-Pacific Region, 62 p with three appendices

Cantor, L W , and Knox, R C , 1986, Septic tank system effects on ground water quality Chelsea, Mich , Lewis Publishers, 336 p

Champ, D R , Gulens, J , and Jackson, R E , 1979, Oxidation-reduction sequences in ground-water flow systems Canadian Journal of Earth Science, v 16, p 12-23

Committee on Water Quality Criteria, 1973, Water quality criteria, 1972 National Academies of Sciences and Engineering, Report EPA-R3-73-033, 594 p

Conover, W J , 1980, Practical nonparametric statistics (2d ed) New York, John Wiley, 493 p

Craig, Harmon, 1961, Isotopic variations in meteoric waters Science, v 133, no 3465, p 1702-1703

Dangberg, Grace, 1975, Conflict on the Carson Carson Valley Historical Society, 467 p

Dansgaard, W , 1964, Stable isotopes in precipitation Tellus, v 16, p 436-467

Davis, J O , 1982, Bits and pieces—The last 35,000 years in the Lahontan area, *in* Madsen, D B , and O'Connell, J F , eds , Lahontan Basin paleoenvironments, Man and environment in the Great Basin Society of American Archaeology Papers, no 2, p 53-75

Davis, J A , and Hayes, K F , 1986, Geochemical processes at mineral surfaces—An overview, *in* Davis, J A , and Hayes, K F , eds , Geochemical processes at mineral surfaces Washington, D C , American Chemical Society, Symposium Series 323, p 2-18

Davis, J A , James, R O , and Leckie, J O , 1978, Surface ionization and complexation at the oxide/water interface—I Computation of electrical double layer properties in simple electrolytes Journal of Colloid Interface Science, v 63, p 480-499

Feth, J H , Roberson, C E , and Polzer, W L , 1964, Sources of mineral constituents in water from granitic rocks, Sierra Nevada, California and Nevada U S Geological Survey Water-Supply Paper 1535-I, 70 p

Fishman, M J , and Friedman, L C , eds , 1985, Methods for determination of inorganic substances in water and fluvial sediments U S Geological Survey Techniques of Water-Resources Investigations, book 5, chap A1, 709 p

Fontes, Jean-Charles, 1980, Environmental isotopes in groundwater hydrology, *in* Fritz, Peter, and Fontes, Jean-Charles, eds , Handbook of environmental isotope geochemistry New York, Elsevier, v 1, p 75-135

Friedlander, Gerhart, Kennedy, J W , Macias, E S , and Miller, J M , 1981, Nuclear and radiochemistry (3d ed) New York, John Wiley, 684 p

Friedman, Irving, Smith, G I , Gleason, James, and Warden, Augusta, 1992, Stable isotope composition of waters in southeastern California—I Modern precipitation Journal of Geophysical Research, v 97, p 5795-5812

Fritz, Peter, and Fontes, Jean-Charles, eds , 1980, Handbook of environmental isotope geochemistry—Introduction New York, Elsevier, v 1, p 1-20

Garcia, K T , 1989, Ground-water quality in Douglas County, western Nevada U S Geological Survey Water-Resources Investigations Report 87-4269, 107 p

Garcia, K T , Gortsema, G C , Pennington, R N , and Preissler, A M , 1992, Water resources data, Nevada, water year 1991 U S Geological Survey Water-Data Report NV-91-1, 481 p

Garside, L J , Hess, Ron, Fleming, K , and Weimer, B S , 1988, Oil and gas developments in Nevada Nevada Bureau of Mines and Geology Bulletin 104, 136 p

Gat, J R , 1980, The isotopes of hydrogen and oxygen in precipitation, *in* Fritz, Peter, and Fontes, Jean-Charles, eds , Handbook of environmental isotope geochemistry New York, Elsevier, v 1, p 21-48

Glancy, P A , 1986, Geohydrology of the basalt and unconsolidated sedimentary aquifers in the Fallon area, Churchill County, Nevada U S Geological Survey Water-Supply Paper 2263, 62 p

Glancy, P A , and Katzer, T L , 1976, Water-resources appraisal of the Carson River Basin, western Nevada Nevada Division of Water Resources, Reconnaissance Report 59, 126 p

Greene, R C , Stewart, J H , John, D A , Hardyman, R F , Silberling, N J , and Sorensen, M L , 1991, Geologic map of the Reno 1° by 2° quadrangle, Nevada and California U S Geological Survey Miscellaneous Field Studies Map MF-2154-A, scale 1 250,000

Guthrie, V A , 1989, Fission-track analysis of uranium distribution in granitic rocks Chemical Geology, v 77, p 87-103

Hardy, M A , Leahy, P P , and Alley, W M , 1989, Well installation and documentation, and ground-water sampling protocols for the pilot National Water-Quality Assessment Program U S Geological Survey Open-File Report 89-396, 36 p

Harrill, J R , and Preissler, A M , 1994, Ground-water flow and simulated effects of development in Stagecoach Valley, a small, partly drained basin in Lyon and Storey Counties, western Nevada U S Geological Survey Professional Paper 1409-H, 74 p

Harill, J R , Welch, A H , and Preissler, A M , 1992, Hydrogeochemical evidence for subsurface inflow to Stagecoach Valley, Lyon County, Nevada, *in* Subitzky, Seymour, ed , Selected papers in the hydrologic sciences, 1988-92 U S Geological Survey Water-Supply Paper 2340, p 179-193

Hastings, D H , 1979, Results of exploratory drilling, northern Fallon Basin, western Nevada, *in* Newman, G W , and Goode, H D , eds , Basin and Range Symposium and Great Basin Field Conference Denver, Colo , Rocky Mountain Association of Geologists and Utah Geological Association, p 515-522

Helling, C S , Zhuang, W , Gish, T J , Coffman, C B , Isensee, A R , Kearney, P C , Hoagland, D R , and Woodward, M D , 1988, Persistence and leaching of atrazine, alachlor, and cyanazine under no-tillage practices Chemosphere, v 17, no 1, p 175-187

Hem, J D , 1985, Study and interpretation of the chemical characteristics of natural water (3d ed) U S Geological Survey Water-Supply Paper 2254, 263 p

Hingston, F J , Atkinson, R J , Posner, A M , and Quirk, J P , 1967, Specific adsorption of anions Nature, v 215, p 1459-1461

Hingston, F J , Posner, A M , and Quirk, J P , 1972, Anion adsorption by goethite and gibbsite—I The role of the proton in determining adsorption envelopes Journal of Soil Science, v 23, p 177-192

Hoffman, R J , Hallock, R J , Rowe, T G , Lico, M S , Burge, H L , and Thompson, S P , 1990, Reconnaissance investigation of water quality, bottom sediment, and biota associated with irrigation drainage in and near Stillwater Wildlife Management Area, Churchill County, Nevada, 1986-87 U S Geological Survey Water-Resources Investigations Report 89-4105, 150 p

Hollander, Miles, and Wolfe, D A , 1973, Nonparametric statistical methods New York, John Wiley, 503 p

Horn, M K , and Adams, J A S , 1966, Computer-derived geochemical balances and element abundances Geochimica et Cosmochimica Acta, v 30, p 279-297

Houghton, J G , Sakamoto, C M , and Gifford, R O , 1975, Nevada's weather and climate Nevada Bureau of Mines and Geology Special Publication 2, 78 p

Hsi, C K D , and Langmuir, Donald, 1985, Adsorption of uranyl onto ferric oxyhydroxides—Application of the surface complexation site-binding model Geochimica et Cosmochimica Acta, v 49, p 1931-1941

Iman, R L , and Conover, W J , 1983, A modern approach to statistics New York, John Wiley, 497 p

Ingram, N L , and Taylor, B E , 1991, Light stable isotope systematics of large-scale hydrologic regimes in California and Nevada Water Resources Research, v 27, p 77-90

James, R O , and Healy, T W , 1972, Adsorption of hydrolyzable metal ions at the oxide-water interface—III A thermodynamic model of adsorption Journal of Colloid Interface Science, v 40, p 65-81

Jenne, E A , 1968, Controls on Mn, Fe, Co, Ni, Cu, and Zn concentrations in soils and water—The significant role of hydrous Mn and Fe oxides, *in* Gould, R F , ed , Advances in chemistry series Washington D C , American Chemical Society, v 73, p 337-387

Johnson, M G , 1977, Geology and mineral deposits of Pershing County, Nevada Nevada Bureau of Mines and Geology Bulletin 89, 115 p

Jones, B F , and Bowser, C J , 1978, The mineralogy and related chemistry of lake sediments, *in* Lerman, Abraham, Lakes—Chemistry, geology, and physics New York, Springer-Verlag, chap 7, p 179-235

Kamineni, D C , 1986, Distribution of uranium, thorium and rare-earth elements in the Eye-Dashwa Lakes Pluton—A study of some analog elements Chemical Geology, v 55, p 361-373

Katzer, T L , 1971, Reconnaissance bathymetric map and general hydrology of Lahontan Reservoir, Nevada Nevada Division of Water Resources, Information Report 9, 1 sheet

Krishnaswami, S , Graustein, W C , Turekian, K K , and Dowd, J F , 1982, Radium, thorium, and radioactive lead isotopes in groundwaters—Application to the *in situ* determination of adsorption-desorption rate constants and retardation factors Water Resources Research, v 18, no 6, p 1663-1675

Krouse, H R , 1980, Sulphur isotopes in our environment, *in* Fritz, Peter, and Fontes, Jean-Charles, eds , Handbook of environmental isotope geochemistry New York, Elsevier, v 1, p 435-472

Langmuir, Donald, 1978, Uranium solution-mineral equilibria at low temperatures with applications to sedimentary ore deposits Geochimica et Cosmochimica Acta, v 42, p 547-569

Latham, A G , and Schwarcz, H P , 1987, The relative mobility of U, Th, and Ra isotopes in the weathered zones of the Eye-Dashwa Lakes granite pluton, northwest Ontario, Canada Geochimica et Cosmochimica Acta, v 51, p 2787-2793

Leventhal, J S , Daws, T A , and Frye, J S , 1986, Organic geochemical analysis of sedimentary organic matter associated with uranium Applied Geochemistry, v 1, no 2, p 241-247

Lico, M S , 1992, Detailed study of irrigation drainage in and near wildlife management areas, west-central Nevada, 1987-90—Part A Water quality, sediment composition, and hydrogeochemical processes in Stillwater and Fernley Wildlife Management Areas U S Geological Survey Water-Resources Investigations Report 92-4024-A, 65 p

Lico, M S , and Rowe, T G , 1991, Radon in ground water of Carson Valley, west-central Nevada, *in* Gundersen, L C S , and Wanty, R B , eds , Field studies of radon in rocks, soils, and water U S Geological Survey Bulletin 1971, p 279-288

Lico, M S , and Seiler, R L , 1994, Ground-water quality and geochemistry, Carson Desert, western Nevada U S Geological Survey Open-File Report 94-31, 91 p

Lico, M S , Welch, A H , and Hughes, J L , 1986, Hydrologic, lithologic, and chemical data for sediment in the shallow alluvial aquifer at two sites near Fallon, Churchill County, Nevada, 1984-85 U S Geological Survey Open-File Report 86-248, 43 p

——1987, Geochemistry of ground water in the shallow alluvial aquifer, Carson Desert, western Nevada, *in* Averett, R C , and McKnight, D M , eds , Chemical quality of water and the hydrologic cycle Chelsea, Mich , Lewis Publishers, p 89-109

Magaritz, Mordeckai, and Luzier, J E , 1985, Water-rock interactions and seawater-freshwater mixing effects in the coastal dunes aquifer, Coos Bay, Oregon Geochimica et Cosmochimica Acta, v 49, p 2515-2525

Mattraw, H C , Jr , Wilber, W G , and Alley, W M , 1989, Quality-assurance plan for the pilot National Water-Quality Assessment Program U S Geological Survey Open-File Report 88-726, 21 p

Maurer, D K , 1985, Gravity survey and depth to bedrock in Carson Valley, Nevada-California U S Geological Survey Water-Resources Investigations Report 84-4202, 20 p

——1986, Geohydrology and simulated response to ground-water pumpage in Carson Valley, a river-dominated basin in Douglas County, Nevada, and Alpine County, California U S Geological Survey Water-Resources Investigations Report 86-4328, 109 p

Maurer, D K , Johnson, A K , and Welch, A H , 1996, Hydrogeology and potential effects of changes in water use, Carson Desert agricultural area, Churchill County, Nevada U S Geological Survey Water-Supply Paper 2436, 106 p

McKenna, S A , 1990, Examination of water quality and groundwater/surfacewater interaction during drought periods, Truckee River, California/Nevada University of Nevada, Reno, unpublished M S thesis, 143 p

Michel, R L , 1989, Tritium deposition in the continental United States, 1953-1983 U S Geological Survey Water-Resources Investigations Report 89-4072, 46 p

Mifflin, M D , and Wheat, M M , 1979, Pluvial lakes and estimated pluvial climates of Nevada Nevada Bureau of Mines and Geology Bulletin 94, 57 p

Moore, J G , 1969, Geology and mineral deposits of Lyon, Douglas, and Ormsby Counties, Nevada Nevada Bureau of Mines Bulletin 75, 45 p

Morgan, D S , 1982, Hydrogeology of the Stillwater geothermal area, Churchill County, Nevada U S Geological Survey Open-File Report 82-345, 94 p

Mullison, W R , 1987, Environmental fate of phenoxy herbicides, *in* Biggar, J W , and Seiber, J N , eds , Fate of pesticides in the environment Agricultural Experiment Station, Division of Agriculture and Natural Resources, University of California, Publication 3320, p 121-131

Nakashima, S , Disnar, J R , Perruchot, A , and Trichet, J , 1984, Experimental study of mechanisms of fixation and reduction of uranium by sedimentary organic matter under diagenetic or hydrothermal conditions Geochimica et Cosmochimica Acta, v 48, p 2321-2329

National Climatic Center, 1986, Climatological data, annual summary, Nevada, 1986 Asheville, N C , U S National Oceanic and Atmospheric Administration, v 101, no 13, 27 p

Nevada Administrative Code, 1992, Public water systems—Quality, December 1980 Nevada Bureau of Health Protection Services, chap 445, amended March 22, 1989, December 3, 1990, October, 14, 1992, 15 p

Nowlin, J O , 1982, Ground-water levels and water quality in an area near Topaz Lake, Douglas County, Nevada U S Geological Survey Open-File Report 80-2046, 76 p

Olmsted, F H , 1985, Ground-water discharge and recharge in the Soda Lakes and Upsal Hogback geothermal areas, Churchill County, Nevada U S Geological Survey Water-Resources Investigations Report 85-4033, 27 p

Olmsted, F H , Welch, A H , Van Denburgh, A S , and Ingebritzen, S E , 1984, Geohydrology, aqueous geochemistry, and thermal regime of the Soda Lakes and Upsal Hogback geothermal systems, Churchill County, Nevada U S Geological Survey Water-Resources Investigations Report 84-4054, 166 p

Otton, J K , Zielinski, R A , and Been, J M , 1989, Uranium in Holocene valley-fill sediments, radon, and helium in waters, Lake Tahoe-Carson Range area, Nevada and California, U S A Environmental Geology and Water Sciences, v 13, p 15-28

Robertson, F N , 1985, Solubility controls of fluorine, barium and chromium in ground water in alluvial basins of Arizona Practical Applications of Ground-Water Geochemistry Conference, Banff, Canada, June 1984, Conference Proceedings, p 96-102

Rowe, T G , and Hoffman, R J , 1990, Wildlife kills in the Carson Sink, western Nevada, winter of 1986-87, *in* Carr, J E , Chase, E B , Paulson, R W , and Moody, D W , comps , National water summary 1987—Hydrologic events and water supply and use U S Geological Survey Water-Supply Paper 2350, p 37-40

Rowe, T G , Lico, M S , Hallock, R J , Maest, A S , and Hoffman, R J , 1991, Physical, chemical, and biological data for detailed study of irrigation drainage in and near Stillwater, Fernley, and Humboldt Wildlife Management Areas and Carson Lake, west-central Nevada 1987-89 U S Geological Survey Open-File Report 91-185, 199 p

Rush, F E , 1968, Index of hydrographic areas in Nevada Nevada Division of Water Resources, Information Report 6, 38 p

———1972, Hydrologic reconnaissance of Big and Little Soda Lakes, Churchill County, Nevada Nevada Division of Water Resources, Information Report 11, 1 sheet

Schaefer, D H , and Whitney, Rita, 1992, Geological framework and ground-water conditions in basin-fill aquifers of the Dayton Valley and Churchill Valley hydrographic areas, western Nevada U S Geological Survey Water-Resources Investigations Report 91-4072, 12 p

Scott, J C , 1990, Computerized stratified random site-selection approaches for design of a ground-water-quality sampling network U S Geological Survey Water-Resources Investigations Report 90-4101, 109 p

Sertic, K A , 1992, Use of chlorofluorocarbon compounds to date ground water—A comparison to the tritium method University of Nevada, Reno, unpublished M S thesis, 102 p

Shacklette, H T , and Boerngen, J G , 1984, Element concentrations in soils and other surficial materials of the conterminous United States U S Geological Survey Professional Paper 1134-A, 18 p

Smales, T J , and Harrill, J R , 1971, Estimated water use Nevada Division of Water Resources, Water for Nevada Report 2, 32 p

Smith, G H , 1943, The history of the Comstock Lode, 1850-1920 University of Nevada Bulletin, Geology and Mining Series 37, 305 p

Smith, J A , Witkowski, P J , and Fusillo, T V , 1988, Man-made organic compounds in the surface waters of the United States—A review of current understanding U S Geological Survey Circular 1007, 92 p

Stabler, Herman, 1904, Report on ground waters of Carson Sink U S Geological Survey Open-File Report, 49 p

Stewart, J H , Carlson, J E , and Johannesen, D C , 1982, Geologic map of the Walker Lake 1° by 2° quadrangle, California and Nevada U S Geological Survey Miscellaneous Field Studies Map MF-1382-A, scale 1 250,000

Stumm, Werner, and Morgan, J J , 1970, Aquatic chemistry—An introduction emphasizing chemical equilibria in natural waters New York, Wiley-Interscience, 583 p

Szalay, A , 1964, Cation exchange properties of humic acids and their importance in the geochemical enrichment of UO and other cations Geochimica et Cosmochimica Acta, v 28, p 1605-1614

Szecsody, J E , Jacobson, R L , and Campana, M E , 1983, Environmental isotopic and hydrogeochemical investigation of recharge and subsurface flow in Eagle Valley, Nevada University of Nevada, Desert Research Institute Publication 42037, 120 p

Taylor, S R , 1964, Abundance of chemical elements in the continental crust Geochimica et Cosmochimica Acta, v 28, p 1273-1285

Thatcher, L L , Janzer, V J , and Edwards, K W , 1977, Methods for determination of radioactive substances in water and fluvial sediments U S Geological Survey Techniques of Water-Resources Investigations, book 5, chap A5, 95 p

Thodal, C E , 1989, Data on ground-water quality, Carson Valley and Topaz Lake areas, Douglas County, Nevada, for year ending September 1986 U S Geological Survey Open-File Report 88-453, 55 p

——1992, Data on ground-water quality, Carson Valley and Topaz Lake areas, Douglas County, Nevada, for year ending September 1987 U S Geological Survey Open-File Report 90-146, 44 p

Thomas, J M , and Lawrence, S J , 1994, Ground-water quality and geochemistry in Dayton, Stagecoach, and Churchill Valleys, western Nevada U S Geological Survey Open-File Report 93-356, 69 p

Thomas, J M , Welch, A H , and Gunderson, L C S , 1990, Distribution and sources of radon-222 in ground water in the Carson River Basin, western Nevada and eastern California, U S A Eos, American Geophysical Union Transactions, v 71, no 43, p 1305

Thomas, J M , Welch, A H , Lico, M S , Hughes, J L , and Whitney, Rita, 1993, Radionuclides in ground water of the Carson River Basin, western Nevada and eastern California, U S A Applied Geochemistry, v 8, p 447-471

Tidball, R R , Briggs, P H , Stewart, K C , Vaughn, R B , and Welsch, E P , 1991, Analytical data for soil and well core samples from the Carson River Basin, Lyon and Churchill Counties, Nevada U S Geological Survey Open-File Report 91-584A, 140 p

Twiss, R H , Elford, C R , James, J W , Mueller, P K , Smith, K C , Warburton, Joseph, and Wong Woo, Harmon, 1971, Climate and air quality of the Lake Tahoe region South Lake Tahoe, Calif , Tahoe Regional Planning Agency and U S Forest Service, 30 p

U S Environmental Protection Agency, 1976, Quality Criteria for Water (red book), EPA 440/9-76-023, 256 p

——1986a, Maximum contaminant levels (subpart B of part 141, National interim primary drinking-water regulations) U S Code of Federal Regulations, title 40, parts 100-149, revised as of July 1, 1986, p 524-528

——1986b, Secondary maximum contaminant levels (section 143 3 of part 143, National secondary drinking-water regulations) U S Code of Federal Regulations, title 40, parts 100-149, revised as of July 1, 1986, p 587-590

——1986c, Secondary maximum contaminant levels (section 14 3 of part 143, National secondary drinking-water regulations) U S Code of Federal Regulations, title 40, parts 100-149, revised as of July 1, 1986, p 587-590

——1991, Proposed rule for primary maximum contaminant levels for radionuclides Federal Register, U S Code of Federal Regulations, July 18, 1991, v 56, no 38, p 33050-33127

U S Geological Survey, 1979, Land use and land cover, 1973, Reno, Nevada-California U S Geological Survey Land Use Map L-64, scale 1 250,000

——1980, Land use and land cover, 1973-79, Walker Lake, Nevada-California U S Geological Survey Open-File Report 80-151-1, scale 1 250,000

——1983, Land use and land cover, 1980, Lovelock, Nevada-California U S Geological Survey Open-File Report 83-111-1, scale 1 250,000

Van Denburgh, A S , 1973, Mercury in the Carson and Truckee River basins of Nevada U S Geological Survey Open-File Report 73-352, 12 p

Verschueren, Karel, 1988, Handbook of environmental data on organic chemicals (2d ed) New York, Van Nostrand Reinhold, 1310 p

Vogel, T M , Criddle, C S , and McCarty, P L , 1987, Transformations of halogenated aliphatic compounds Environmental Science and Technology, v 21, no 8, p 722-736

Welch, A H , 1994, Ground-water quality and geochemistry in Carson and Eagle Valleys, western Nevada and eastern California U S Geological Survey Open-File Report 93-33, 99 p

Welch, A H , and Lico, M S , 1988, Aqueous geochemistry of ground water with high concentrations of arsenic and uranium, Carson River basin, Nevada Chemical Geology, v 70, no 1/2, p 19

Welch, A H , Lico, M S , and Hughes, J L , 1988, Arsenic in the western United States Ground Water, v 26, no 3, p 333-347

Welch, A H , Plume, R W , Frick, E A , and Hughes, J L , 1989, Ground-water quality in the Carson River basin, Nevada and California—Basin overview and analysis of available data through 1987 U S Geological Survey Open-File Report 89-382, 115 p

Welch, A H , Szabo, Zoltan, Parkhurst, D L , Van Metre, P C , Mullin, A H , 1995, Gross-beta activity in ground water Natural sources and artifacts of sampling and laboratory analysis Applied Geochemistry, v 10, no 5, p 491-503

Welch, A H , Thomas, J M , and Gunderson, L C S , 1990, Distribution and sources of uranium in ground water in the Carson River basin, western Nevada and eastern California, U S A Eos, American Geophysical Union Transactions, v 71, no 43, p 1305

Wershaw, R L , Fishman, M J , Grabbe, R R , and Lowe, L E , eds , 1987, Methods for the determination of organic substances in water and fluvial sediments U S Geological Survey Techniques of Water-Resources Investigations, book 5, chap A3, 80 p

Whitney, Rita, 1994, Data on ground-water quality in the Carson River Basin, western Nevada and eastern California, 1987-90 U S Geological Survey Open-File Report 94-39, 82 p

Willden, Ronald, and Speed, R C , 1974, Geology and mineral deposits of Churchill County, Nevada Nevada Bureau of Mines and Geology Bulletin 83, 95 p

Zachara, J M , Cowan, C E , and Resch, C T , 1991, Sorption of divalent metals on calcite Geochimica et Cosmochimica Acta, v 55, p 1549-1562

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Merlyn Paine

From: Merlyn Paine [redacted]
Sent: Tuesday, October 10, 2017 1:20 PM
To: shicks@carson.org
Cc: Robb Fellows; 'dschulz@carson.org'
Subject: Pinion Hills OPLMA BLM parcel transfer: Storm Drainage concerns
Attachments: 89778-aerial_of_south_carson Feb 2017.jpg; FW: East Side Stormwater systems - Pursia Road; 8-11-2014 storm damage Pursia Road off of Deer Run 007 Paine Driveway.JPG; 8-11-2014 storm damage Pursia Road off of Deer Run 009 South side.JPG; 8-11-2014 storm damage Pursia Road off of Deer Run 010 South side Paine property.JPG; 8-11-2014 storm damage Pursia Road off of Deer Run 011 South side Spencer property.JPG; 8-11-2014 storm damage Pursia Road off of Deer Run 012 North side.JPG; 8-11-2014 storm damage Pursia Road off of Deer Run 018 Intersection.JPG; 8-11-2014 storm damage Pursia Road off of Deer Run 019 Intersection and ponding.JPG; 8-11-2014 storm damage Pursia Road off of Deer Run 022 north side.JPG; 8-11-2014 storm damage Pursia Road off of Deer Run 023 south side.JPG; 8-11-2014 storm damage Pursia Road off of Deer Run 024 south side undermining driveway.JPG; 8-11-2014 storm damage Pursia Road off of Deer Run 025 south side covering driveway.JPG; 8-11-2014 storm damage Pursia Road off of Deer Run 012 North side.JPG; 89778-aerial_of_south_carson Feb 2017.jpg; 8-11-2014 storm damage Pursia Road off of Deer Run 007 Paine Driveway.JPG; 8-11-2014 storm damage Pursia Road off of Deer Run 010 South side Paine property.JPG; 8-11-2014 storm damage Pursia Road off of Deer Run 008 Paine Driveway.JPG; 8-11-2014 storm damage Pursia Road off of Deer Run 008 Paine Driveway.JPG

Stephanie Hicks
Real Property Manager
Carson City Public Works
3505 Butti Way
Carson City, NV 89701

10/10/2017

Via email and hard copy delivered.

RE: OPLMA Pinion Hills Parcel Disposal and Drainage Concerns

Ms. Hicks:

This letter is my second response to your letter to the Pinion Hills Subdivision property owners, dated August 16, 2017, regarding OPLMA.. My first letter addressed concerns related to limited aquifer supply and recharge in this neighborhood; this letter addresses drainage issues. I look forward to both of these elements (aquifer supply and recharge, and storm drainage) being thoroughly explored in the upcoming NEPA evaluation and Board of Supervisor's decision-making on parcel disposal.

Opening development on fourteen parcels in our immediate neighborhood is of great concern as there is a long history of mud/rock flows in this area. We currently have five homes on Pursia Road; the OPLMA proposal will add four more uphill properties that will channel runoff past our homes. As you must be aware, the Pinion Hills Subdivision has no effective design for storm drainage and whenever it rains in any significant amount, the mud flows down several neighborhood streets and not only scours out the road ditches and covers driveways with mud and rock, but also comes to rest on Deer Run Road which requires frequent post-storm debris removal. The mud and debris also flows across Deer Run Road and onto the downslope properties. The significant 8-11-2014 storm damaged the ditches, undermined driveways, damaged the Pursia Road blacktop, and began to impact private property. Please see attached photographs of the 8-11-2014 storm damage.

Regarding this incident, I wrote the attached letter to Rob Fellows, Carson City Storm Water Engineer, dated 8/17/2014. After several phone calls from residents in this area, a team from the Engineering Department visited this area to view the damage inflicted by the storm. I am sure that there is a filed report in the Engineering Department documenting their findings.

Please note that this mud/rock flow situation has happened numerous times before and certainly since 2014. Other than some contouring on the north side of the intersection, the City has done nothing to correct the drainage impacts since the August, 2014 incident; it is an ongoing problem for the residents here every time we have significant rains. It should be noted as well that the deposited dirt is removed from the intersection and is NOT replaced onto the uphill rights-of-way; thus, there is a net loss of materials from Pursia Road rights-of-way. As a result, the dirt and rocks that protect the Pursia Road private property boundaries are being removed, thus causing likelihood of further erosion to the roadway and to our parcels.
The point is that the problem will only get worse when more homes are built above and around us unless runoff is better guided and stored.

Please also note the attached aerial photograph from the February, 2017 storm which resulted in significant flooding here on the East Side of the Carson River. The subdivision to the right in the photograph is our Pinion Hills Subdivision. I include this as a reminder of the extensive water collection and drainage that this area experiences from significant storms.

The residents of Pinion Hills live within the City limits, vote within the jurisdiction, and pay property taxes to the City (including storm water assessments which primarily benefit the West Side). We understand that the City has an interest in selling these fourteen parcels and allowing development, both for the sales revenues and the ongoing tax assessments on the new properties. However, the City has a responsibility to see that Pinion Hills residents are not disadvantaged by your selling these fourteen parcels and allowing development.

If your City Planning staff coordinates with City Engineering, and your Maintenance Departments, they will undoubtedly have records as to how often residents have called asking for clean-up after storms, and how often Maintenance has sent a grader, bulldozer and dump truck to clean up the Pursia Road/Deer Run Road intersection. I strongly encourage you to speak to your Engineering and Maintenance Departments to get copies of their records regarding this area. Please keep in in mind that the records you access will only address the City recorded responses to date; with the addition of more parcels, the drainage and clean-up problems will be compounded.

Thank you for your attention.

Merlyn L. Paine

Attachments: Letter, Paine to Fellows, August 17, 2014
Feb 2017 Aerial Photo
8-11-2014 photographs of storm drainage issues, 7 photos

Parcel 010-087-16
6025 Pursia Road
Carson City, NV 89701

Merlyn Paine

From: Merlyn Paine [redacted]
Sent: Sunday, October 08, 2017 8:18 PM
To: [redacted]
Subject: FW: East Side Stormwater systems - Pursia Road

From: Merlyn Paine [redacted]
Sent: Sunday, August 17, 2014 6:30 PM
To: Robb Fellows
Cc: dschulz@carson.org
Subject: East Side Stormwater systems - Pursia Road

Dear Robb:

I want to thank you and the other public works managers for responding to residents' concerns regarding the damage from the 8-11-2014 storm. It was gratifying to see you here inspecting Pursia Road early in the morning on the 13th, and, further, appreciate the time that we had to discuss the typical storm damage to this street. As you are aware, the response of Justin Tiearney and his street crew in the Pursia Road clean-up was exceptional.

The Pinion Hills subdivision has no design for storm drainage and whenever it rains in any significant amount, the mud flows down the sides of Pursia Road, and not only scours out the road ditches and covers driveways with mud and rock, but also comes to rest in prodigious amounts on Deer Run Road, which then requires repeated clean-up to keep the arterial open. Precipitation finally collects and pools on the right of way on Deer Run, or runs over the road and flows onto the properties on the west side of the roadway. While the West Side has been able to utilize federal funds from FEMA and other entities to help in developing the storm water system, the East Side has been given a low priority for any system development. While it is in the community spirit for all of us to pay stormwater taxes which primarily benefit the West Side, I look forward to the time when our stormwater tax payments are utilized for the benefit of those in our area; a storm water handling system is clearly needed in the Pinion Hills Subdivision.

Thank you again for your time and your personal response to our concerns. I look forward to discussing this further with you at a future time.

Sincerely,
Merlyn

Merlyn Paine
6025 Pursia Road
Carson City, NV 89701

Feb-2017 flooding

Silver Saddle Road

upslope ↗

Pinion Hills Subdivision

Carson River Road →

← Carson River

Paine

August 2014
storm

Pursia
Road

south side

looking
uphill

↑ East

← Driveway

Paine

August 2014
storm

↑ West

South
side

Pursia
Road

August 2014
Storm

↑ west

Pursia
Road

South Side
Pursia Rd
erosion and
damage

Paine

August 2014
storm

Pursia
Road

North side
Pursia Rd

erosion and
damage

Paine

August 2014
Storm

↑ North

Pursia
Road

Driveway - covered with mud, rocks and debris.

Paine

August 2014
storm

↑ North

Pursia Rd

gullying

Driveway - covered with
inches of mud, Rocks and debris.

Paine

August 2014
Storm

Deer Run Road - Pursia Road
Intersection - South side.

Looking West

Deer Run
Road.

Pursia Road

Paine

August 2014
Storm Damage

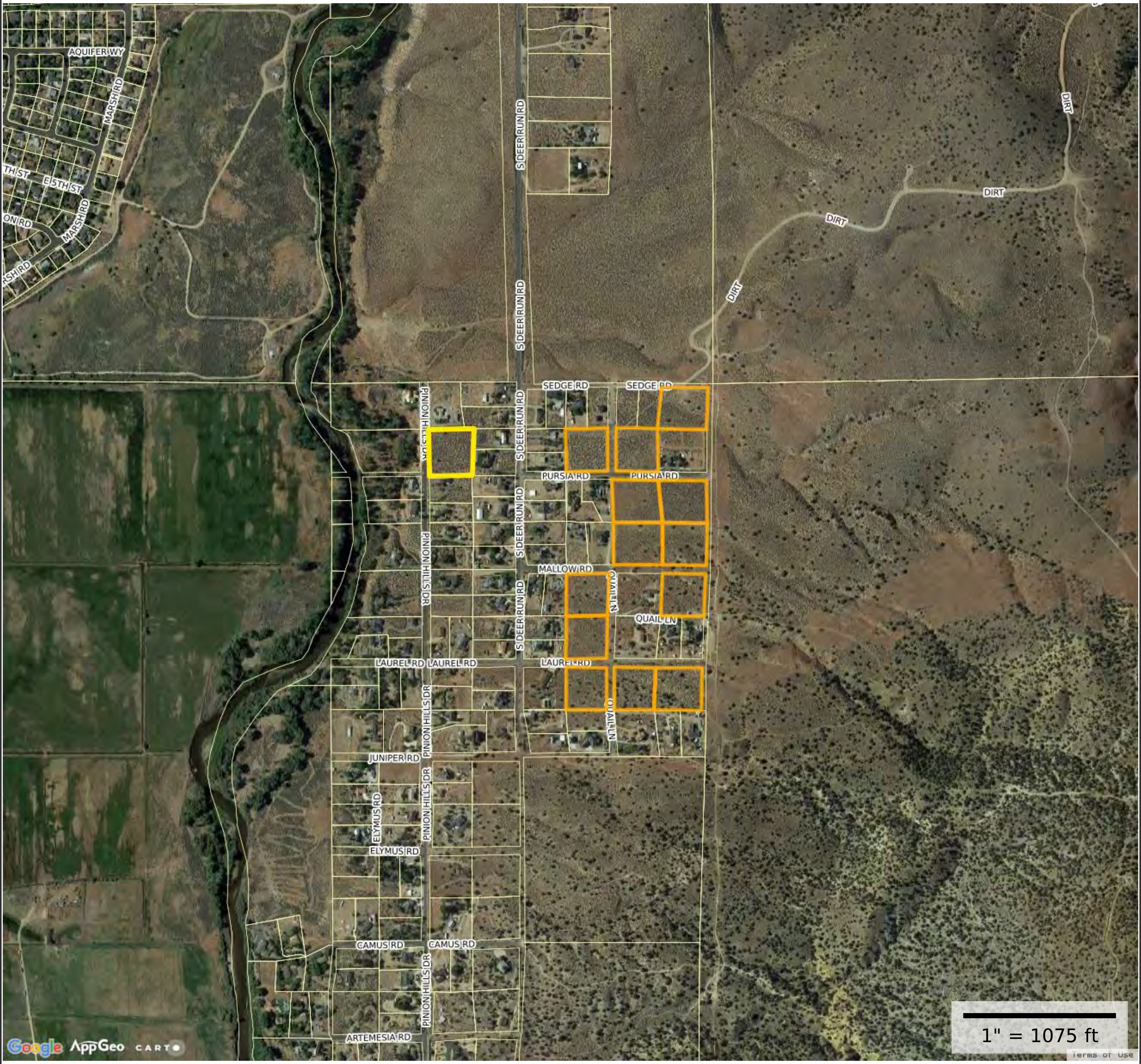
Deer Run Rd-
Pursia Road
Intersection-
South side

Pursia
Road

Mud, Rocks,
debris
Ponding

Paine

Pinion Hills Vicinity



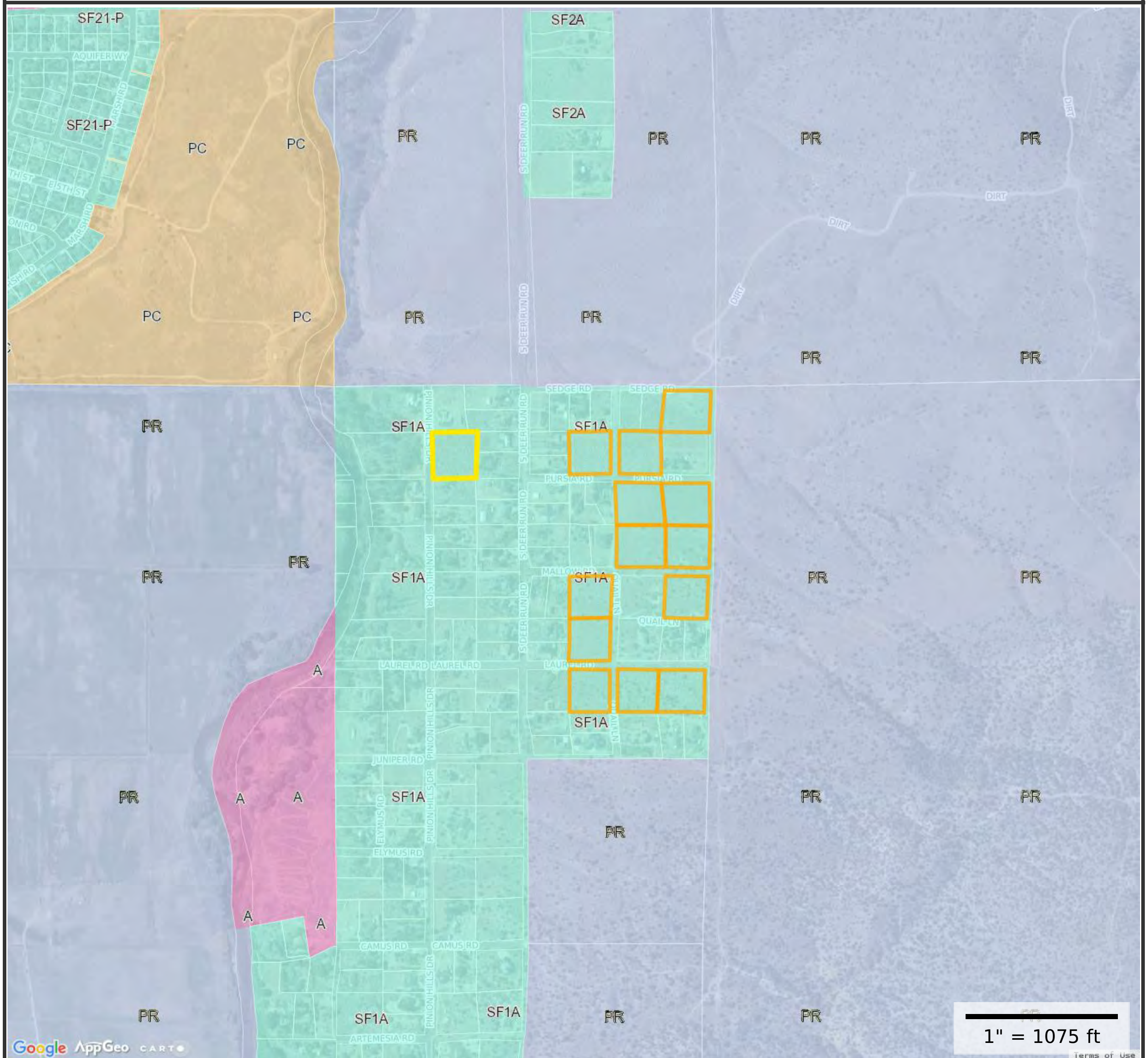
Property Information

Property ID	01008204
Location	1251 PINION HILLS DR
Owner	B L M

MAP FOR REFERENCE ONLY
NOT A LEGAL DOCUMENT

Parcels updated 06/06/2017
Properties updated 06/06/2017

Pinion Hills Zoning



Property Information

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MAP FOR REFERENCE ONLY
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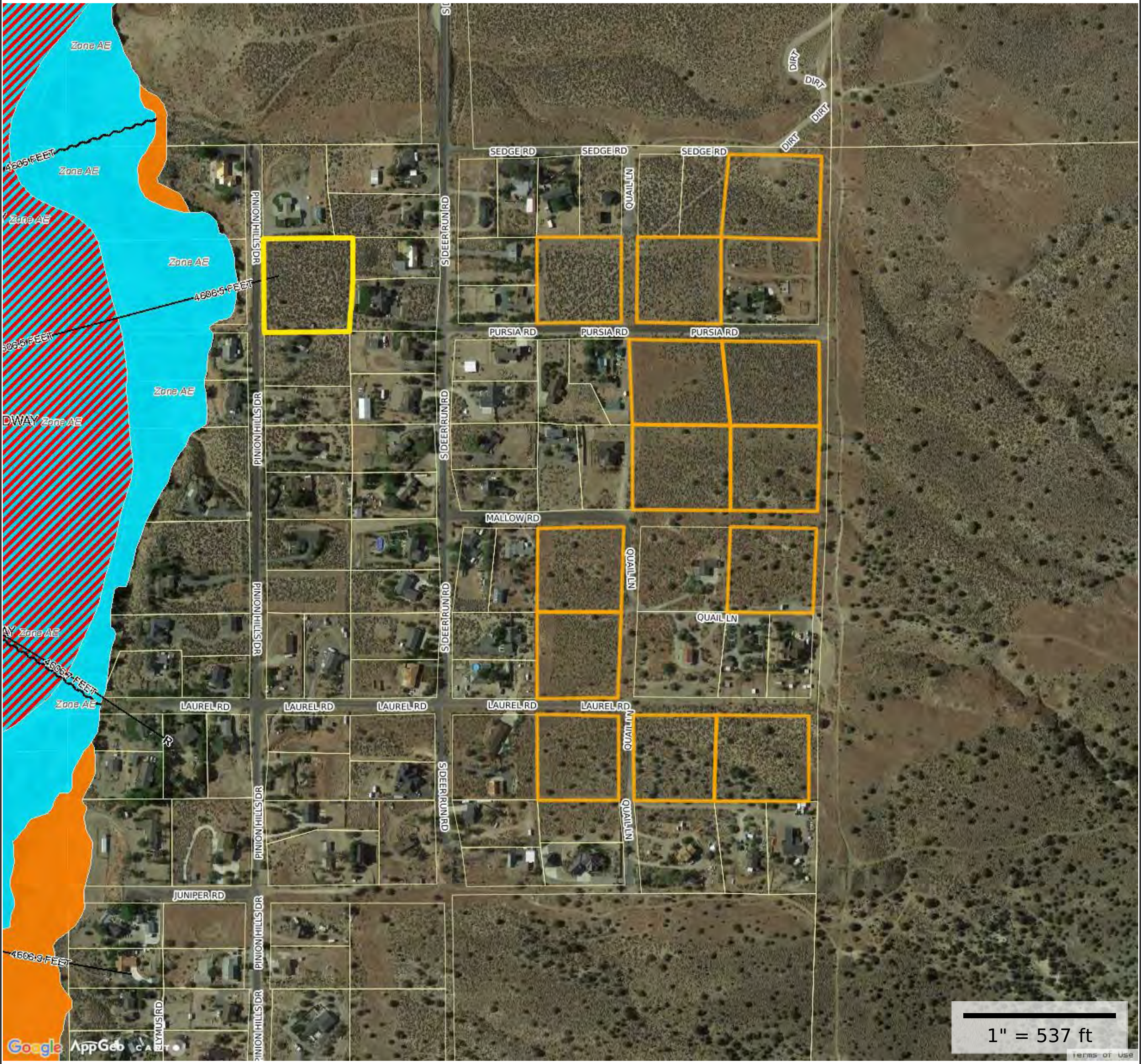
Carson City , NV makes no claims and no warranties, expressed or implied, concerning the validity or accuracy of the GIS data presented on this map.

Parcels updated 06/06/2017
Properties updated 06/06/2017

Pinion Hills Hazards



Property Information

Property ID	01008204
Location	1251 PINION HILLS DR
Owner	B L M

MAP FOR REFERENCE ONLY
NOT A LEGAL DOCUMENT

Parcels updated 06/06/2017
Properties updated 06/06/2017

CARSON CITY NEVADA
Consolidated Municipality and State Capital
PUBLIC WORKS

Pinion Hills Neighborhood

Open House Fact Sheet – August 29, 2017

Why is BLM selling these parcels?

On January 6, 2009, the "Omnibus Public Land Management Act of 2009" (OPLMA) was enacted by Congress to determine the desired future uses of federal properties surrounding Carson City. This bill was the result of three years of collaboration between City officials, interest groups and Congressional delegates with technical input from federal agencies. During this time, there was a vigorous and extensive citizen participation program consisting of more than 15 public information workshops and advisory board meetings where opportunities were available to present written comments or where oral and written testimony was received.

The purpose of the bill was to improve land management throughout Carson City and help fulfill the community's long-term plan for growth and conservation. During that process, these parcels were identified for sale.

Why were these parcels identified for sale?

These parcels are located adjacent to existing development and at the "urban interface" with development making them isolated and difficult to manage by BLM. The sale of these parcels will create continuous land management units, is consistent with BLM's management plans and the Carson City Master Plan, and reduces the "checkerboard" ownership pattern of federal, city, and private lands.

What is Carson City's role in the sale?

Carson City's role in this process is to collect feedback from the neighborhood, answer any questions about the process and allowable uses, and bring this information to the Board of Supervisors for direction.

What are the parcels zoned and what is allowed there?

The parcels are zoned SF1A (Single-Family 1 acre) with a master plan designation of low density residential. Allowable uses include a single family residence or a park. Accessory uses include accessory farm structures, accessory structures, agricultural use, animals and fowl, guest building, home occupation and individual or subdivision recreation use (swimming pool, tennis court).

What are the development requirements?

All parcels will need to accommodate natural drainage. Some of the parcels will need formal drainage and access easements for existing drainage facilities. There is no sewer and water available; therefore, the parcels will need to meet requirements for well and septic. New wells must be approved by the City and State and meet all requirements. Paved access will be required at time of the development if it is not already present.

Some parcels may be dividable. However, each parcel would have to be evaluated and if divided, a denitrifying septic system would be required. If a parcel is divided or it serves more than four parcels, the road would have to be brought up to City standards.

Are these properties located in a flood zone?

There are no mapped flood hazards for these parcels. However, all parcels will need to accommodate natural drainage. Some of the parcels will need formal drainage and access easements for existing drainage facilities.

3505 Butti Way, Carson City, NV 89701 (775) 887-2355 FAX (775) 887-2112
Operations: Water, Sewer, Streets, Wastewater, Landfill, Environmental Engineering, Transportation, Capital Projects

Do adjacent property owners get the right of first refusal for purchasing these parcels?

The OPLMA legislation specified that the parcels would be sold through a competitive bidding process. Adjacent property owners can bid on the parcels through that process.

Has an environmental review been completed?

No, an environmental review has not been completed but will be required prior to sale. The environmental and cultural resource evaluation will be performed consistent with the National Environmental Policy Act (NEPA) and the National Historic Preservation Act. The NEPA process will include opportunity for public comment.

Have these parcels been surveyed yet or listed and advertised?

No, not yet. Once the NEPA is complete, BLM will move forward with putting the parcels up for sale. All parcels will be reviewed for survey needs and surveyed prior to disposal, if needed.

What will the parcels sell for?

The parcels will be appraised by Office of Valuation Services (another Department of Interior agency) to determine Fair Market Value. Fair Market Value is determined by Highest and Best Use and considers known constraints on use, such as access. Appraisals will be done using Uniform Appraisal Standards for Federal Land Acquisitions. Parcels will be sold for no less than the Fair Market Value determined by the appraisal.

How will the parcels be sold?

Parcels will be sold for no less than the Fair Market Value determined by the appraisal. Notice of Realty Action will be published in Federal Register and sent to interested parties. Sale of the parcels will be through a competitive bidding process.

How long before the parcels are available for sale?

It will take approximately 2 years from the time of the City's recommendation to complete the NEPA review, appraisal, and prepare the parcels for sale.

Where are the proceeds going?

Funds from the sale will be used to cover the BLM's costs for processing the sales. After this deduction, the legislation directs the Secretary of Interior to reinvest the remaining proceeds of these land sales back into important public projects. Ninety-five percent of the proceeds will be used to acquire environmentally sensitive lands and protect archaeological resources in Carson City. The remaining five percent of the proceeds will go to Nevada's general education program.

Helpful Resources:

Appraisal Standards:
https://www.justice.gov/file/408306/download

43 CFR 2710:
www.eCFR.gov

Section 2609 of the Omnibus Public Land Management Act of 2009:
https://www.congress.gov/111/plaws/publ11/PLAW-111publ11.pdf

Contact Information:

Stephanie Hicks, Real Property Manager
Carson City Public Works
3505 Butti Way
Carson City, Nevada 89701
Phone: (775) 283-7904
Email: shicks@carson.org

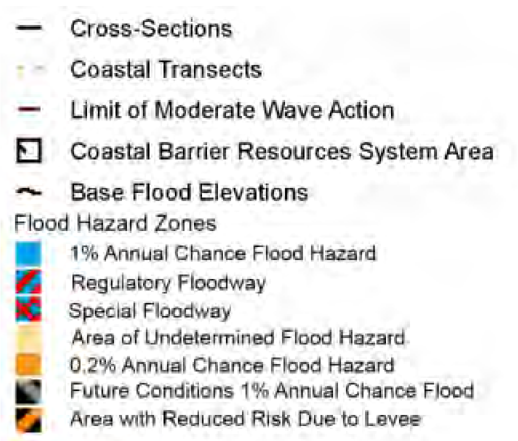
Map Theme Legends

USGS Linear Faults

LINEAR FAULTS

- CLASS B YEARS
- < 1,600,000 YEARS
- < 750,000 YEARS
- < 130,000 YEARS
- < 15,000 YEARS
- < 150 YEARS
- UNKNOWN

FEMA Flood Zones (Zoom in to View)



FEMA Map Service Center - See FEMA FIRM Panels theme for Effective Date

Map Theme Legends

Current Zoning

- Agricultural
- Airport Industrial Park
- Conservation Reserve
- Downtown Mixed Use
- General Commercial
- General Industrial
- General Industrial Airport
- General Office
- Limited Industrial
- Mobile Home Park
- Multi-Family Apartment
- Multi-Family Duplex
- Neighborhood Business
- Public
- Public Community
- Public Neighborhood
- Public Regional
- Residential Office
- Retail Commercial
- Single Family
- Tourist Commercial

Carson CIty Zoning Boundary Layer. Layer was created using the Carson City Parcel Boundary File and the Carson City Street Centerline File.