AGENDA
SHAKOPEE PUBLIC UTILITIES COMMISSION
REGULAR MEETING
October 7, 2024
at 5:00 PM ***

1. **Call to Order** at 5:00pm in the SPU Service Center, 255 Sarazin Street
   1a) Roll Call

2. **Communications**

3. **Consent Agenda**
   C=> 3a) Approval of September 9, 2024 Minutes (GD)
   C=> 3b) Approval of October 7, 2024 Agenda (JK)
   C=> 3c) October 7, 2024 Warrant List (KW)
   C=> 3d) Monthly Water Dashboard for August 2024 (LS)
   C=> 3e) 2024 Flushing Program Progress Map (LS)
   C=> 3f) Nitrate Report – Advisory (LS)
   C=> 3g) Res #2024-29 Resolution Approving Payment for the Pipe Oversizing Costs on the Watermain Project: Highview Park 1st Addition (JA)
   C=> 3h) August 31, 2024 - Financials Report (KW)
   C=> 3i) MMPA August 2024 Meeting Update (GD)

   * Motion to approve the Consent Agenda

4. **Public Comment Period.** Please step up to the table and state your name and address for the record.

5. **Liaison Report** (JD)

6. **Reports: Water Items**
   6a) Water System Operations Report – Verbal (LS)
   6b) Backflow Penalty Appeal Response - Res#2024-30 A Resolution Making Findings of Fact and Determining the Appeal Submitted by Mikhail Stalmakov (GD)

   * Motion of denial of Mr. Stalmakov's appeal to review the $150 backflow penalty for failure to comply with SPU's Backflow Prevention and Cross-Connection Control Policy and approval of Res #2024-30, A Resolution Making Findings of Fact and Determining the Appeal Submitted by Mikhail Stalmakov.

   6c) McGuire and Sunset Streets and Utilities Feasibility Report (RH)

   * Motion from the Commission with the desired lateral and looping requirements for the McGuire Circle, McGuire Court neighborhood

   6d) Tank 9 Reject All Bids and Rebid (RH)

   * Motion to Reject al Bids for the Tank 9 project and rebind the project.

7. **Reports: Electric Items**
   7a) Electric System Operations Report – Verbal (BC)
   7b) Electric Long Range Plan Presentation (GD)

8. **Reports: General**

- 8a) Marketing/Key Accounts Report – Verbal (SW)
- 8b) Dave Berg Consulting, LLC Rate Study (KW)
- 8c) General Manager Report – Verbal (GD)
- 8d) General Manager Performance Evaluation (JK) **

** Motion to go to go to closed session under Minnesota Statutes, Section 13D.05, subd.3(a) to evaluate the performance of the General Manager**.**

**** A portion of this meeting may be closed under Minnesota Statutes, Section 13D.05, subd.3(a) to evaluate the performance of the General Manager.**

9. **Items for Future Agendas**

10. **Tentative Dates for Upcoming Meetings**

- October 21, 2024 Workshop
- November 4, 2024
- December 2, 2024

11. **Adjournment**

*** A Commissioner may participate via interactive technology from the following location, which shall be open and accessible to the public during the meeting:

MINUTES OF THE
SHAKOPEE PUBLIC UTILITIES COMMISSION
September 9, 2024
Regular Meeting

1. Call to Order. President Krieg called the September 9, 2024 meeting of the Shakopee Public Utilities Commission to order at 5:00 P.M. President Krieg, Vice President Letourneau, Commissioner DuLaney, Commissioner Fox, and Commissioner Mocol were present.

2. Communications. Greg Drent, General Manager, noted an SPU communication to a customer appealing the backflow prevention penalty.

3. Consent Agenda. Mr. Drent noted that item 8d NES WTP Site Search Update: Shakopee Gravel/Hawkins potential site will be removed from the agenda. Commissioner Mocol pulled items 3j and 3. In response to a question from Commissioner DuLaney on item 3d, Lon Schemel, Water Superintendent, noted the large variance in water usage. Commission Mocol moved to approve the consent agenda, as amended:

(a) August 5, 2024 minutes;
(b) September 9, 2024 Agenda;
(c) September 9, 2024 Warrant List;
(d) Monthly Water Dashboard for July 2024;
(e) Reservoir Structure Inspections;
(f) July 31, 2024 Financials Report;
(g) 2025 Budget Timeline;
(h) Statement of Work – Audit Services: Clifton, Larson Allen LLP (CLA);
(i) MMPA August 2024 Meeting Update;
(l) Controlled Substance and Alcohol Testing Policy

Commissioner Fox seconded the motion. Ayes: Krieg, Letourneau, DuLaney, Fox, and Mocol. Nays: None. For items (3j) Res# 2024-27 Resolution of Appreciation to Gregory Triplett and (3k) Res #2024-28 Resolution of Appreciation to Cynthia Nickolay, Commissioner Mocol recognized both employees for their many years of service. She then moved approval of items 3j and 3k; Vice President Letourneau seconded the motion. Ayes: Krieg, Letourneau, DuLaney, Fox, and Mocol. Nays: None.

4. Public Comment Period. No public comments were offered.

5. Customer Appeal of Backflow Penalties. Mr. Drent noted that a customer disputed the $150 penalty for the failure to test and submit documentation of the backflow prevention device under SPU's Backflow Prevention and Cross-Connection Control Policy. Under SPU's appeal process, Mr. Drent responded to the customer's appeal by letter and the customer wished to address the Commission on the issue. Mikhail Stalmakov spoke about the $150 penalty for failure to complete the backflow prevention device testing and certification for his lawn sprinkler system. Mr. Stalmakov noted that the law passed in 2015 refers to fire sprinkler systems and not lawn

sprinkler systems. He reasoned that a lawn sprinkler does not have high pressure and has no chance to get into the public water system because the pressure ends when the water is turned off. Mr. Stalmakov also stated that state testing requirements apply to devices installed in 2016 or later and that his system was installed before 2016. He asked the Commission to remove the $150 penalty.

President Krieg noted that it would be helpful for SPU staff to gather additional information, including the applicable portions of the code, information to understand the risks of contaminating the public water system, and potential federal Clean Water Act applicable provisions. Commissioner Mocol moved to direct staff to respond to the information presented and to come back with a draft of findings and determination for the Commission to consider at a future meeting. Commission DuLaney seconded the motion. Ayes: Krieg, Letourneau, DuLaney, Fox, and Mocol. Nays: None.

6. 2024 Comprehensive Water Plan Update. Joseph Adams, Planning and Engineering Director, introduced Chad Katzenberger from SEH, Inc. to present the final comprehensive water plan. Mr. Katzenberger noted that in evaluating a long-range capital improvement plan for water facilities, Section 7 presents three separate tables that assume growth in the current city limits, serving the areas of Louisville Township as a wholesale customer, and fully developing the water system to serve Louisville Township. Mr. Adams explained that this document will be used in future analysis of trunk water charges and water capacity charges, as well as capital improvement plans and budgets. Commissioner Fox moved to accept the report as presented and use it as a guide when preparing the Commission's capital improvement plans and water system operating budget. Commissioner Mocol seconded the motion. Ayes: Krieg, Letourneau, DuLaney, Fox, and Mocol. Nays: None.

7. Water Report. Mr. Schemel reported that hydrant painting is almost complete with 40 hydrants out of 200 left to paint. He noted that due to an equipment delay, Pumphouse 23 is not expected to be operational until mid-February. Mr. Schemel reported that SPU has received testing results of 333 backflow systems, with 103 failures in test results. He noted that approximately 1,300 systems remain to be tested.

8. AMI Water Meter Installations – Actions for Failure to Install. Sharon Walsh, Director of Key Accounts/Marketing/Special Projects, provided an update as to 370 residential customers who have not scheduled the AMI meter installation as of August 28, 2024. She noted that SPU has sent three notices by mail; SPU staff also placed a door hanger notice on each customer's door. Under the policy approved by the Commission in February 2023, SPU will generate a phone call to these customers and if they do not comply within 14 days, the penalty of $100 per month will follow, with a return of certain funds upon compliance.

9. Jackson Township Park Water Service Request by the City of Shakopee. Mr. Adams gave an overview of the request to install a water service in Jackson Town Hall to provide drinking water in a park facility to be owned and maintained by the City of Shakopee. Commissioner Fox moved approval of the water service to the City of Shakopee park facility consistent with

Resolution #814. Commissioner Mocol seconded the motion. Ayes: Krieg, Letourneau, DuLaney, Fox, and Mocol. Nays: None.

10. Request o Authorized Use of Reclaimed Water in Car Wash. Mr. Adams explained that Take 5 Car Wash has asked to use reclaimed water in its new automated car wash. If approved, this measure would reduce the Met Council SAC unit determination for SAC and WCC fees. The process requires a letter from the community supporting the application and necessary inspections and record keeping. Commissioner Mocol moved to authorize the General Manager to proceed as described in the staff report and to direct staff to update the Water Policy Manual to incorporate the requirements to allow reclaimed water use in certain situations. Commission Fox seconded the motion. Ayes: Krieg, Letourneau, DuLaney, Fox, and Mocol. Nays: None.

11. Liaison Report. Commissioner DuLaney noted that he attended the Minnesota Municipal Utilities Association summer conference, which included informative sessions on legislative updates, emergency communications, and cybersecurity. He noted that City staff prepared a memorandum of understanding for Jackson Township Commons, which will operate as a City park.

12. Electric Report. Brad Carlson, Electric Superintendent, provided project updates, including the roundabout at Eagle Creek, joint trench work at Highview and Arbor Bluffs, underground facilities at Sand Venture Pool, replacing battery pad in substation, permanent power at St. Francis, lighting at Co Rd 78 and Co Rd 69, and 101 and removing overhead and installing underground facilities at Shenandoah. Mr. Carlson noted that staff is busy installing electric AMI meters, and in that process they have come across some problems requiring electricians to help replace sockets. He reported twelve outages since the last Commission meeting, mostly from storms, with three smaller outages related to cable issues.

13. Marketing/Key Accounts Report. Ms. Walsh reported that SPU has installed approximately 8,426 electric AMI meters and 4,365 AMI water meters. She noted that in investigating a small percentage of water meters with leaks, no consistent cause has been determined. She also reported that all AMI inventory has been received, including 33,500 meters and 11,500 com-modulars. Ms. Walsh noted that the State launched a new conservation platform, and SPU has submitted its 2023 results and its 2025 plans.

14. Organizational Chart Changes 2024 – 2025. Mr. Drent described recommended changes to the organizational chart, which included creating a Technical Service Supervisor position, relocating the Dispatch/CSR position to customer service/billing, and creating a Communication Specialist position. He noted that these changes will not have a financial impact on the 2024 budget and will be included in the 2025 budget process. Vice President Letourneau moved to approve the 2024 – 2025 Organizational Chart as presented. Commissioner DuLaney seconded the motion. Ayes: Krieg, Letourneau, DuLaney, Fox, and Mocol. Nays: None.

15. General Manager Report. Mr. Drent provided an update on pending items, including budget and capital improvement planning, compensation analysis, meeting with a potential large power user, and updates to the Employee Handbook. He noted that SPU will prepare a two-year Year in Review report in early 2025. Mr. Drent asked for two Commissioners to volunteer to participate in an informal working group to assist with the budget process. President Krieg and Vice President Letourneau volunteered to help.

16. Adjourn. Motion by Commissioner Fox, seconded by Commissioner Mocol, to adjourn. Ayes: Krieg, Letourneau, DuLaney, Fox, and Mocol. Nays: None.

Greg Drent, Commission Secretary

Proposed As Consent Item **3b**

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Proposed As Consent Item 3c

SHAKOPEE PUBLIC UTILITIES COMMISSION

WARRANT LISTING

October 7, 2024

By direction of the Shakopee Public Utilities Commission, the Secretary does hereby authorize the following warrants drawn upon the Treasury of Shakopee Public Utilities Commission:

WEEK OF 09/06/2024

AAR BUILDING SERVICE CO.	$4,298.63	SEPTEMBER SPU BLDG CLEANING
ALTEC INDUSTRIES INC	$8,358.03	FREIGHT DUE ON HARNESS ORDER
ASTLEFORD INTL TRUCKS	$122,301.50	WO#2697 NEW DUMP TRUCK CHASIS
BG MINNESOTA, INC.	$166.72	IN-FORCE(E)
BORDER STATES ELECTRIC SUPPLY	$44,608.85	ST LIGHT FOUNDATIONS
CITY OF SHAKOPEE	$5,000.00	NOTE: EDA FOR HAWKINS PROPERTY AQUIS
DSI/LSI	$445.11	SEPTEMBER GARBAGE SVC
EUROFINS EATON ANALYTICAL, LLC	$2,485.00	QUARRY WELL PHAS TESTING
GRAINGER INC	$49.85	SAW BLADE (E)
HAWKINS INC	$3,169.47	CHLORINE CYLINDERS
HENRICKSEN PSG	$4,094.54	INSTALL/STANDING DESKS FOR OFFICE
HREXPERTISEBP LLC	$131.25	AUGUST HR CONSULTING SERVICES
INNOVATIVE OFFICE SOLUTIONS	$508.38	OFFICE SUPPLIES
INT'L UNION OF OPER ENGINEERS LOCAL 49	$812.00	HRS WORKED BTEN 7/20 & 8/16 2024
INTEGRATED PROCESS SOLUTIONS, INC	$960.92	SCADA ITEM REPAIR(W)
IRBY - STUART C IRBY CO	$1,448.92	POLYMER CUTOUT-CREDIT ($295.28) APPLIED
JT SERVICES	$5,852.25	PULL TAPE(E)
KATAMA TECHNOLOGIES, INC.	$562.50	AMI 2472 GENERAL CONSULTING FOR AUGUST
KRB DEVELOPMENT VIII LLC	$33,154.25	WO#2632 WHISPERING WATER 2ND ADDN WM
LA MARCHE MFG CO	$3,290.00	FERRORESONANT CHARGER FOR SUB REPAIR
LLOYD'S CONSTRUCTION SERVICES	$1,028.50	8/13-8/14 2024 30 YD DEMO/CONSTRUTION
LOCATORS & SUPPLIES INC	$1,288.91	RED MARKING FLAGS(E)
LOFFLER COMPANIES - 131511	$1,400.79	AMI WO#2718 WATER METER INSTALL NOTICES
MINN VALLEY TESTING LABS INC	$260.00	WATER TESTING NITRATES
MMUA	$150.00	NW LINEMAN TUITION DYLAN RICHARDS
MPOWER TECHNOLOGIES, INC.	$874.50	AUG MPOWER CUSTOMER SVCS
NAPA AUTO PARTS	$183.09	DELO 15W40 GAL/HYDRAULIC FLUID(E)
GERRY NEVILLE	$92.46	REIMBURSE 138 MILES
CINDY NICKOLAY	$93.80	REIMBURSE 140 MILES
OLSEN CHAIN & CABLE, INC.	$985.31	CHAIN SLING,RATCHET PLUS(E)
RESCO	$2,486.88	CONNECTOR PEDESTAL
CODY SCHUETT	$42.83	REIMBURSE GATORADE FOR CREW STORM WORK
SCOTT COUNTY	$2,311.88	WO2715 MORAINE ADDN WM PLANREV INSPECTIO
VERIZON WIRELESS	$4,098.89	AUGUST CELL BILL
VIVID IMAGE, INC.	$650.00	SEPT RETAINER PERIOD 9/1-9/30 2024
WESCO RECEIVABLES CORP.	$1,198.84	CREDIT FOR RTN ON RMA 002304
NCPERS GROUP LIFE INS.	$192.00	AUG. PREMIUMS FOR LIFE INS.
ONE TECH ENGINEERING INC.	$8,400.00	7/29-8/2/2024 TIME WORKED
CENTERPOINT ENERGY - ACH	$674.24	GAS USAGE 255 SARAZIN 7/8-8/7 2024
FURTHER - ACH	$212.74	FLEX CLAIM REIMBURSEMENT
DELTA DENTAL PLAN OF MN	$5,611.80	AUG. DENTAL PREMIUMS
FURTHER - ACH	$225.50	AUG. HSA ADMIN. FEES
PRINCIPAL LIFE INS. COMPANY	$4,695.52	LTD AND STD PREMIUMS FOR AUG.
MINNESOTA LIFE	$1,130.94	MN LIFE AUG. PREMIUMS
HEALTHPARTNERS	$70,713.81	SEPT. PREMIUMS, AUG CHARGE MONTH
PAYROLL DIRECT DEPOSIT 09.06.24	$139,716.58	
BENEFITS & TAXES FOR 09.06.24	$131,128.28	
Total Week of 09/06/2024	**$621,546.26**	

WEEK OF 09/13/2024

CREDIT REFUNDS	$9,002.45	CREDIT REFUNDS
ABDO LLP	$3,262.50	AUGUST FS ACCOUNTING SERVICE
HENRY AHMED	$500.00	ENERGY STAR HEATING/COOLING REBATE
AMERICAN WATER WORKS ASSN	$240.00	MEMBERSHIP RENEWAL 12/1/24-11/30/25
ANNETTE STANEK	$926.25	SPU 2023 YR/REVIEW COVER DESIGNS(E)
MARK BANWART	$30.00	RECYCLING REBATE
BARNA GUZY & STEFFEN LTD	$3,575.00	WO#2844 E.SUBSTATION LEGAL FEES
BARR ENGINEERING CO.	$5,602.25	WO#2683 TANK 9 PROF SVCS JUNE-JULY
BORDER STATES ELECTRIC SUPPLY	$157,030.30	SLEEVE ALUM TENSION SPLICE
WENDY BOUTELL	$105.00	ENERGY STAR REFRIGERATOR REBATE
BRADLEY CARLSON	$266.72	PER DIEM/REIMBURSE MILEAGE MMUA RODEO
MERVYN CARRABON	$500.00	ENERGY STAR HEATING/COOLING REBATE
LYNN CASSEM	$500.00	ENERGY STAR HEATING/COOLING REBATE
CENTURY PROMOTIONAL ADVERTISING LLC	$480.64	SPU UNIFORM CLOTHING
CHOICE ELECTRIC INC	$3,482.20	AMI WO#2472 METER SOCKET
CITY OF SHAKOPEE	$533,164.83	AUG 204 SW $413,700.19 / SD $119,464.64
CITY OF SHAKOPEE	$338,400.00	AUGUST PILOT MONTHLY TRF FEE
CITY OF SHAKOPEE	$1,080.04	AUG STORM DRAINAGE/SPU PROPERTIES
CORE & MAIN LP	$3,187.09	PULSE CABLE FOR METERS(W)
DAKOTA SUPPLY GROUP	$1,762.94	TRANSFORMER SAFETY LIFT
HEATHER DEW	$500.00	ENERGY STAR COOLING/HEATING REBATE
JEFFREY DEWAELE	$500.00	ENERGY STAR COOLING/HEATING REBATE
DGR ENGINEERING	$1,071.50	WO#2837 SS31 LATERAL 3PH EXT 2024
DIVERSIFIED ADJUSTMENT SERVICES INC	$44.57	DUE TO COLLECTION AGENCY AUG STMT
MARTIN DROUILLARD	$325.20	MILEAGE REIMBURSEMENT UMMA FEB 24
BROC EBLI	$143.10	IRRIGATION CONTROLLERS REBATE
EGAN COMPANY	$8,478.13	WO#2894 MNDOT SP7005-127 CAMERA SVC REFU
GARY FEE	$500.00	ENERGY STAR COOLING/HEATING REBATE
FERGUSON US HOLDINGS, INC.	$220.60	PTFE PIPE THRD TAPE/WOG 2PC SWT(W)
FLYTE HCM LLC	$10.00	AUGUST COBRA
FORMSTACK, LLC	$1,437.48	GOLD-ANNUAL CHARGE 8/1/24-7/31/25
FRONTIER ENERGY, INC.	$6,223.00	AUG 2024 C&I IMPLENTATION/PROG MGMT
TREVOR L GEIS	$500.00	ENERGY STAR HEATING/COOLING REBATE
GOPHER STATE ONE-CALL	$1,205.55	AUGUST TICKETS
GRAINGER INC	$566.91	MEASURING WHEEL(E)
GRAYBAR ELECTRIC COMPANY INC	$21.88	2 TERMINAL ADAPTER
HAWKINS INC	$2,227.31	WATER WO#2851 PUMP
CYNTHIA HUTH	$75.00	ENERGY STAR REFRIGERATOR REBATE
IRBY - STUART C IRBY CO	$99,407.59	BRONZE VISE CONNECTORS(E)
LAKE REGION CUSTOM WOODWORKS	$10,730.21	25% DOWN PYMT WOODWORK COMM ROOM WO2848
AUSTEN LEADSTROM	$75.00	ENERGY STAR REFRIGERATOR REBATE
DAN LEBENS	$500.00	ENERGY STAR HEATING/COOLING REBATE
LLOYD'S CONSTRUCTION SERVICES	$614.25	RENTAL PD 8/6/24-9/3/24 30 YD DEMO & CON
LOCATORS & SUPPLIES INC	$795.64	RED CONSTRUCTION MARKING PAINT(E)
LOFFLER COMPANIES - 131511	$1,418.98	AMI WO 2718 WATER MTR INSTALL INSERTS
M E SIMPSON CO., INC	$18,805.00	LARGE WATER METER ANNUAL TESTING
BRIAN MCCUSKER	$175.00	ENERGY STAR CLOTHES WASHER REBATE
CINDY MENKE	$317.07	REIMB HALLOWEEN DECOR TRICK/TRUNK W CITY
MICHELS UTILITY SERVICES	$8,639.27	WO#2778 TRENCH @ ARBOR BLUFF 1ST ADDN
MINN VALLEY TESTING LABS INC	$260.00	WATER TESTING NITRATES
MINNESOTA SECURITY CONSORTIUM	$212.50	SEPT 2024-JAN 2025 PRO LIC SEC AWARNESS
NARDINI FIRE EQUIPMENT CO INC	$793.96	INSPECTION NOVEC SYSTEM
GERRY NEVILLE	$87.10	REIMBURSE 130 MILES
CINDY NICKOLAY	$116.58	REIMBURSE 174 MILES
NISC	$33,509.54	AUGUST PRINT SERVICES
NORTHERN STATES POWER CO	$3,512.72	AUGUST POWER BILL
NORTHERN TOOL & EQUIP CATALOG HOLD INC	$59.97	BUCKETEER
OFFICE OF MNIT SERVICES	$734.01	AUGUST WAN MONTHLY INVOICE
JOE OHNSTAD	$500.00	ENERGY STAR COOLING/HEATING REBATE
JAC PAPINEAU	$175.00	ENERGY STAR CLOTHESWASHER REBATE
PITNEY BOWES GLOBAL FINANCIAL SERVIC	$1,214.52	3RD QTR LEASE BILLING PD 6/30/24-9/29/24
VLADAN PULEC	$75.00	ENERGY STAR REFRIGERATOR REBATE
RESCO	$119,463.03	PEDESTAL PRIMARY ENCLOSURE 1 PHASE
RICE LAKE CONSTRUCTION GROUP	$303,146.80	WO#2581 PUMPHOUSE #23 - PYMT# 7
ROERS GENERAL CONTRACTING	$32,311.35	ENERGY CONSERVATION LIGHTING ETC
RW BECK GROUP, INC, LEIDOS ENG. LL	$39,617.75	AUG 2024 SPU LONG RANGE PLANNING STUDY
CATHERINE SABLE	$500.00	ENERGY STAR HEATING/COOLING REBATE
DAVE SEEKINS	$50.00	ENERGY STAR CLOTHES WASHER REBATE
SPENCER FANE LLP	$15,569.50	AUGUST 2024 LEGAL FEES
SRF CONSULTING GROUP, INC.	$1,638.99	WO#2885 PROFESSIONAL SVCS JUNE
FREDERICK STEFFEN	$154.05	IRRIGATION CONTROLLERS REBATE
TESCO - THE EASTERN SPECIALITY COMPANY	$250.00	4TH QTR 10/1-12/31 2024 ADAPTIV SERVICES
TOM KRAEMER, INC	$580.00	AMI WO2472 SEPT MONTHLY RENT
UPS STORE # 4009	$209.18	WATER DEPT CHEMICAL SHIPMENT
RAJENDRA VALLAMKONDU	$150.00	ENERGY STAR DISHWASHER REBATE

WEEK OF 09/13/2024 *(CONTINUED)*

VALLEY-RICH CO., INC	$2,083.03	REPAIR VALVE @ P.H. 6
ALISHA VELAND	$100.00	ENERGY STAR DISHWASHER REBATE
VERIZON WIRELESS	$106.87	BILLING PD 8/6-9/5 2024
VESTIS FIRST AID & SAFETY SUPPLIES LOCK	$1,285.34	1ST AID KITS/CABINETS
JAMIE VON BANK	$309.60	PER DIEM/REIMBURSE MMUA RODEO
WATER CONSERVATION SERVICE INC	$766.75	LEAK LOCATES @ 2062 CHESTER ST/SHAKO AVE
WESCO RECEIVABLES CORP.	$4,964.93	COLORED 3M TAPE(E)
XCEL ENERGY	$4,519.65	7/24-8/22 2024 ELECTRIC SVC VALLEY PARK
AMERICAN NATL BANK MASTERCARD ACH	$13,209.47	AUGUST CC STMT
FIRST DATA CORPORATION	$9,043.44	AUGUST CC FEES
FURTHER - ACH	$41.13	MEDICAL CLAIM FLEX REIMB
MMPA C/O AVANT ENERGY	$4,490,382.49	AUGUST POWER BILL
MN DEPT OF REVENUE ACH PAYMENTS	$408,460.00	AUG 2024 SALES & USE TAX PAYABLE
Total Week of 09/13/2024	**$6,718,790.70**	

WEEK OF 09/20/2024

APPLE FORD OF SHAKOPEE	$683.21	OIL CHG WATER TRK#630
BADGER STATE INSPECT, LLC	$2,066.00	TOWER 1 DISH PRECON/FINAL WALK
BIRDS LAWN CARE LLC	$3,843.99	AUGUST LAWN CARE
BORDER STATES ELECTRIC SUPPLY	$324,005.85	AMI WO#2472 ELETRIC METERS
CDW GOVERNMENT LLC	$1,569.59	MONITORS/DESK MOUNT
CITY OF SHAKOPEE	$6,751.68	AUGUST FUEL BILL
COMCAST CABLE COMM INC.	$2.30	CABLE BREAKROOMS 9/17-10/16 2024
CORE & MAIN LP	$77.51	RUBBER METER WASHERS(W)
CORVAL CONSTRUCTORS, INC.	$1,508.00	REPLACED /REWIRED FUSE(E)
CUSTOMER CONTACT SERVICES	$813.50	ANSWERING SVC 9/17-10/14 2024
DAILY PRINTING, INC.	$1,450.00	AMI#2718 SPU WATER MTR DOOR HANGERS
FERGUSON US HOLDINGS, INC.	$362.27	PARTS FOR WATER DEPT
GRAINGER INC	$274.99	SOLENOID ASSEMBLY,SLOAN
INNOVATIVE OFFICE SOLUTIONS	$557.50	CREDIT FOR OVERPYMT
INTERSTATE ALL BATTERY CTR	$195.73	BATTERY(E)
IRBY - STUART C IRBY CO	$36,922.60	WO 2891 1000 ALUM 15KV CABLE
JOHNSON CONTROLS FIRE PROTECTION LP	$650.25	ANNUAL CONTRACT SVCS 10/1/24-9/30/25
JT SERVICES	$1,457.65	CARRIAGE BOLT SET(E)
MIDWEST SAFETY COUNS, INC.	$642.23	DISPOSABLE LATEX GLOVES(W)
MINN DEPT OF COMMERCE	$10,558.75	2ND QTR FISCAL YR 2025 INDIRECT ASSESSME
MINN VALLEY TESTING LABS INC	$331.00	WATER TESTING NITRATES
MINNESOTA SECURITY CONSORTIUM	$3,000.00	VCISO SVCS FOR Q3 (JUL, AUG, SEPT) 2024
MPOWER TECHNOLOGIES, INC.	$350.00	AMI 247S & 2718 CLOUD HOSTING SERVER
NAGEL COMPANIES LLC	$16,520.00	WO#2861 BORE @ WATER PARK
GERRY NEVILLE	$168.17	REIMBURSE 251 MILES
CINDY NICKOLAY	$22.11	REIMBURSE 33 MILES
SHORT ELLIOTT HENDRICKSON INC	$11,398.64	WO#2868 SHPUC 11th Ave W WaterMain Imp
TPG REAL ESTATE LLC	$105.00	REFUND PRIVTE HYDRANT INSPECTION
VERIZON	$577.56	TRUCK TRACKING
WESCO RECEIVABLES CORP.	$4,657.73	CONNECTOR
KELLEY WILLEMSSEN	$649.17	REIMB FOR 2024 COMP TRENDS SURVEY
FURTHER - ACH	$192.31	FLEX DAYCARE CLAIM REIMB
PAYROLL DIRECT DEPOSIT 09.20.24	$134,811.96	
BENEFITS & TAXES FOR 09.20.24	$126,791.88	
Total Week of 09/20/2024	**$693,969.13**	

WEEK OF 09/27/2024

JACK ANDERSON	$500.00	ENERGY STAR COOLING/HEATING REBATE
KURT ANDERSON	$500.00	ENERGY STAR COOLING/HEATING REBATE
ARAMARK REFRESHMENT SERVICES INC	$117.09	COFFEE FOR BREAKROOMS
B & B TRANSFORMER INC	$16,995.00	150 KVA 3 PHSE TRANSFORMER
BORDER STATES ELECTRIC SUPPLY	$22,578.76	AMI 2472 SOFTWARE
BRADLEY CARLSON	$354.72	PER DIEM ORLANDO FL/REIMB MILEAGE
GREG DRENT	$276.50	PER DIEM DULUTH MN 9/2024
MIKE ENRIGHT	$349.48	PER DIEM MARSHALL MN OH SCHOOL/REIM FUEL
TIMOTHY FRIESEN	$500.00	ENERGY STAR COOLING/HEATING REBATE
ANNE GILSDORF	$500.00	ENERGY STAR COOLING/HEATING REBATE
MATTHEW GRIEBEL	$206.50	PER DIEM MARSHALL MN MMUA OH SCHOOL
BRAD GUSTAFSON	$206.50	PER DIEM MARSHALL MN MMUA OH SCHOOL
DAVID HAGEN	$540.48	PER DIEM DULUTH MN/REIMB MILEAGE
JACKLYN HANSON	$540.48	PER DIEM DULUTH MN/REIMB MILEAGE
HAWKINS INC	$11,598.82	HYDROFLUOSILIC ACID/CHLORINE
MATTHEW HEMKEN	$500.00	ENERGY STAR COOLING/HEATING REBATE
BECKY HOFFARTH	$105.00	ENERGY STAR REFRIGERATOR REBATE
LARRY HOLM	$500.00	ENERGY STAR COOLING/HEATING REBATE
DAVID KELLOGG	$50.00	ENERGY STAR CLOTHESWASHER REBATE
TYRA KRATOCHVIL	$354.50	PER DIEM ORLANDO FL NICS 2024 CONF
RAYMOND LIGHTFOOT	$500.00	ENERGY STAR COOLING/HEATING REBATE
MID AMERICA METER INC	$175.00	5/8X3/4 SHOP TEST DP(W)
MINN VALLEY TESTING LABS INC	$166.00	WATER TESTING COLIFORM
MN DEPT OF HEALTH	$30,369.33	3RD QTR 2024 COMM WATER SUPPLY SVC CONN
ALEXANDER MOSTOV	$125.00	ENERGY STAR CLOTHESWASHER REBATE
TONY MYERS	$540.48	PER DIEM DULUTH MN/REIMB MILEAGE
GERRY NEVILLE	$178.89	REIMB 267 MILES
NORTHERN TOOL & EQUIP CATALOG HOLD INC	$69.97	PIPE WRENCH ALUM
PUMP & METER SERVICE, INC.	$1,031.41	HYDRANT MTR #464624 RET'D REFUND DUE
RADIAN RESEARCH INC	$1,127.50	CUSTOMER SITE RECERTIFICATION SVC
JUSTIN ROTERT	$206.50	PER DIEM MARSHALL MN MMUA OH SCHOOL
CODY SCHUETT	$310.50	PER DIEM ORLANDO FL 9/15-9/19 2024
BRANDON SCHWARTZ	$276.50	PER DIEM DULUTH MN SCHOOLING
SCOTT COUNTY TREASURER	$2,100.00	SEPT FIBER
ELLE SEAVER	$206.50	PER DIEM MARSHALL MN MMUA OH SCHOOL
DAVE SEEKINS	$125.00	ENERGY STAR CLOTHES WASHER REBATE
T & R ELECTRIC SUPPLY CO INC	$21.38	PCB SAMPLE(E)
TEST GAUGE & BACKFLOW SUPPLY INC	$542.63	REPAIR KITS(W)
PENNY THIELHORN	$405.95	PER DIEM ORLANDO FL/REIMB TRANSPORTATION
USABLUEBOOK	$703.40	HACH DR300 CHLORINE
MICHAEL VOURLOS	$347.43	PER DIEM ORLANDO FL NISC CONF 2024
RYAN WERMERSKIRCHEN	$499.45	PER DIEM ORLANDO FL/REIM RENTAL CAR
TONY ZIERMAN	$500.00	ENERGY STAR COOLING/HEATING REBATE
FURTHER - ACH	$192.31	DAYCARE FLEX CLAIM RIMB
ZAYO GROUP, LLC	$4,975.58	T1 LINE,SPU,PIKE LAKE,S SUB
Total Week of 09/27/2024	**$102,970.54**	
Grand Total	**$8,137,276.63**	

Kelly Willemssen

Presented for approval by: Director of Finance & Administration

Approved by General Manager

Approved by Commission President

Proposed As Consent Item **3d**

Monthly Water Dashboard

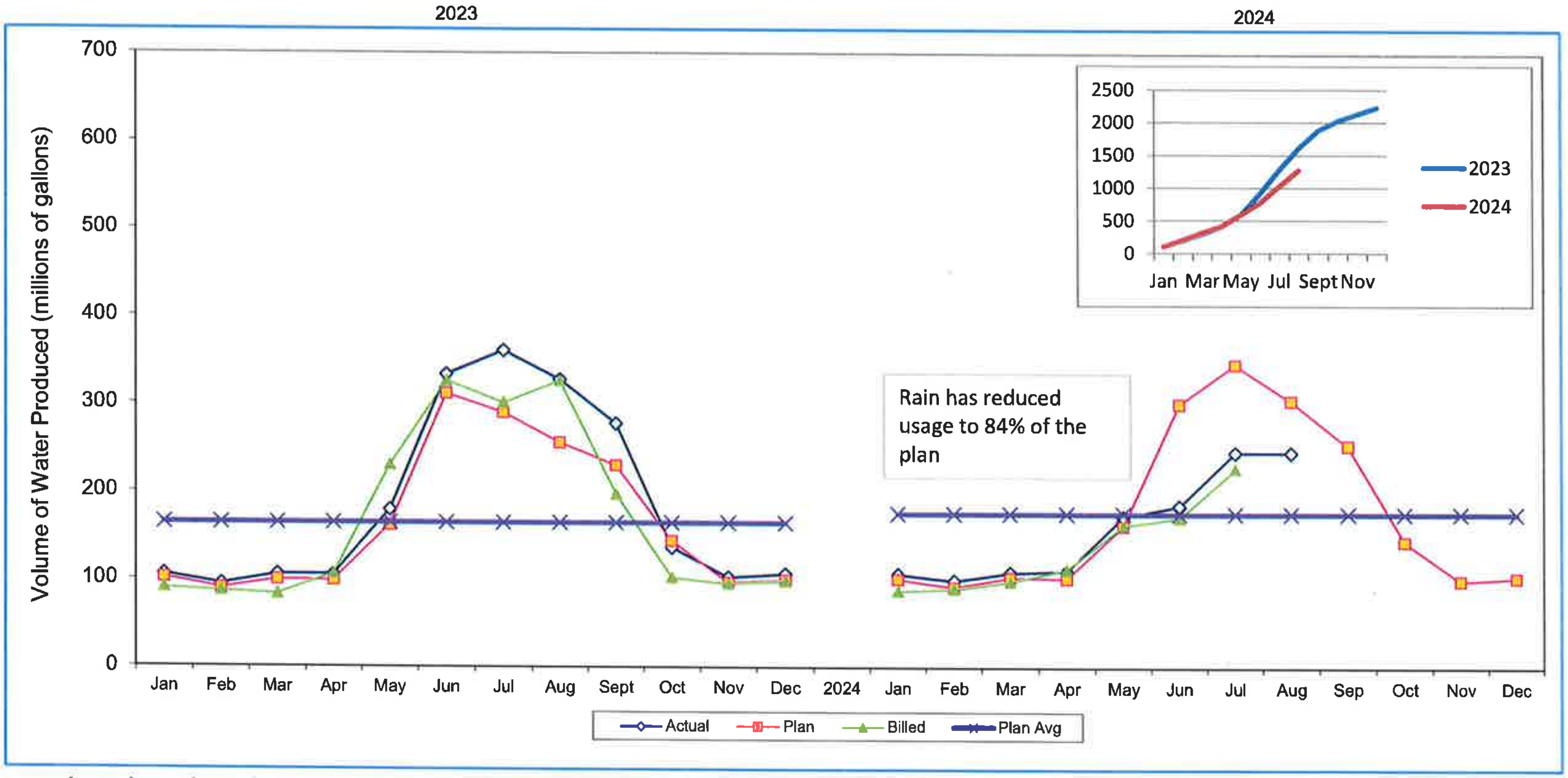
As of: August 2024 **Shakopee Public Utilities Commission**

ALL VALUES IN MILLIONS OF GALLONS

Element/Measure Water Pumped/Metered

Last 6 months actuals	109	111	173	185	246	246

Monthly Avg	
2021	173
2022	167
2023	187



2023	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Actual	106	95	106	106	180	334	361	328	278	137	103	107
Plan	102	90	100	99	162	312	290	256	230	144	97	100
YTD % *												
Billed	91	87	84	107	231	327	302	327	198	103	96	99

2024	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Actual	107	100	109	111	173	185	246	246				
Plan	101	92	103	102	162	301	346	305	254	144	100	103
YTD % *	106%	107%	107%	107%	107%	91%	85%	84%				
Billed	88	91	99	113	163	172	228					

* Actual gallons pumped vs. Plan

Proposed As Consent Item **3e**

SPU Shakopee Public Utilities

PO Box 470 • 255 Sarazin S...
Shakopee, Minnesota 55379
Main 952.445-1988 • Fax 952.445-7767
www.shakopeeutilities.com

TO: Greg Drent, General Manager

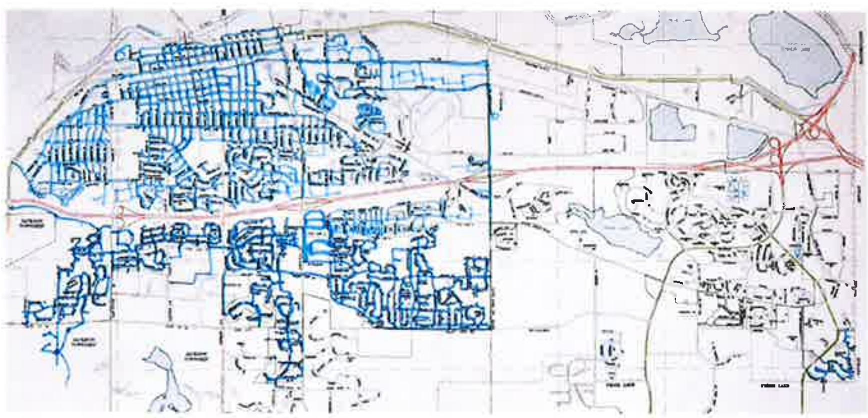
FROM: Lon R. Schemel, Water Superintendent

SUBJECT: 2024 Flushing Program Progress

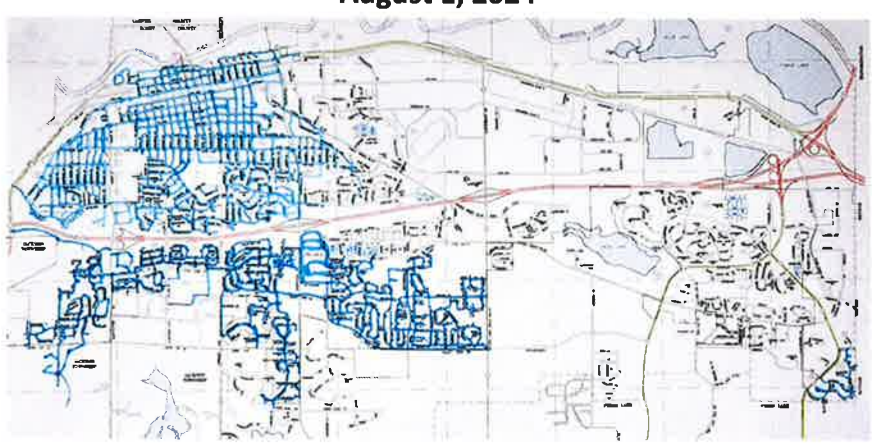
DATE: October 3, 2024

Completed flushing areas are highlighted in blue as of the dates indicated.

October 3, 2024



August 1, 2024



Proposed As Consent Item **3f**

Shakopee Public Utilities

PO Box 470 • 255 Sarazin Street
Shakopee, Minnesota 55379
Main 952.445-1988 • Fax 952.445-7767
www.shakopeeutilities.com

TO: Greg Drent, General Manager

FROM: Lon R. Schemel, Water Superintendent

SUBJECT: Nitrate Results - Advisory

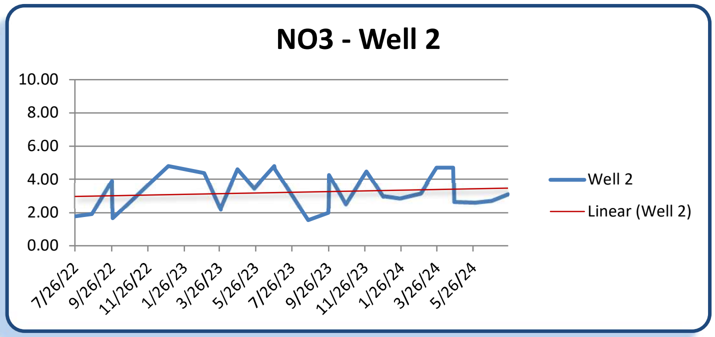
DATE: October 4, 2024

Attached are the latest nitrate test results for our production wells. The analyses provided are for the prior 2 years of data collected with trend graphs.

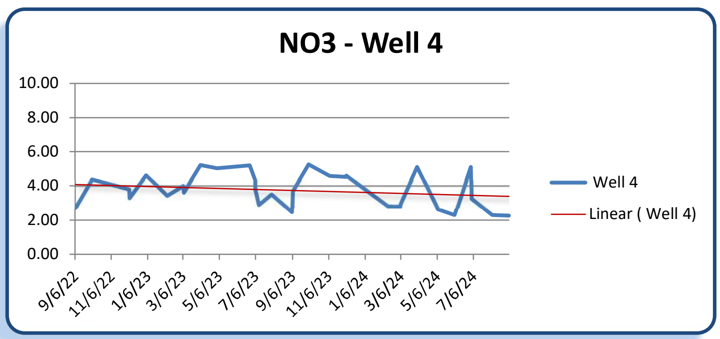
MN Department of Health
800-818-9318

Shakopee Public Utilities Commission
Water Department
Nitrate Results
Reported in mg/L

Location	Sample Collected	Results Received	Results	Lab
2	7/26/22	8/4/22	**1.78**	MVTL
2	8/23/22	9/9/22	**1.90**	MVTL
2	9/26/22	10/25/22	**3.90**	MDH
2	9/27/22	10/10/22	**1.66**	MVTL
2	12/30/22	4/6/23	**4.80**	MDH
2	2/28/23	3/10/23	**4.38**	MVTL
2	3/28/23	4/4/23	**2.18**	MVTL
2	3/28/23	6/13/23	**2.30**	MDH
2	4/25/23	5/4/23	**4.60**	MVTL
2	5/23/23	6/7/23	**3.44**	MVTL
2	6/26/23	7/19/23	**4.80**	MDH
2	6/27/23	6/30/23	**4.61**	MVTL
2	8/22/23	10/4/23	**1.55**	MVTL
2	9/25/23	10/26/23	**2.00**	MDH
2	9/26/23	10/4/23	**4.26**	MVTL
2	10/24/23	10/26/23	**2.51**	MVTL
2	11/28/23	12/7/23	**4.48**	MVTL
2	12/26/23	12/27/23	**2.96**	MVTL
2	12/26/23	2/8/24	**3.00**	MDH
2	1/23/24	1/29/24	**2.86**	MVTL
2	2/27/24	2/29/24	**3.15**	MVTL
2	3/25/24	4/11/24	**4.70**	MDH
2	4/22/24	5/8/24	**4.70**	MDH
2	4/23/24	4/25/24	**2.65**	MVTL
2	5/28/24	6/10/24	**2.62**	MVTL
2	6/25/24	7/24/24	**2.72**	MVTL
2	7/23/24	8/14/24	**3.12**	MVTL



4	9/6/22	9/19/22	**2.87**	MVTL
4	9/6/22	10/25/22	**2.70**	MDH
4	10/4/22	10/11/22	**4.38**	MVTL
4	12/5/22	2/9/23	**3.80**	MDH
4	12/6/22	12/8/22	**3.30**	MVTL
4	1/3/23	3/10/23	**4.62**	MVTL
4	2/7/23	3/10/23	**3.43**	MVTL
4	3/6/23	4/6/23	**4.00**	MDH
4	3/7/23	3/10/23	**3.62**	MVTL
4	4/4/23	4/6/23	**5.23**	MVTL
4	5/2/23	5/5/23	**5.03**	MVTL
4	6/26/23	9/27/23	**5.20**	MDH
4	7/5/23	7/19/23	**4.35**	MVTL
4	7/5/23	7/19/23	**3.80**	MDH
4	7/11/23	7/14/23	**2.90**	MVTL
4	8/1/23	8/7/23	**3.51**	MVTL
4	9/5/23	9/14/23	**2.47**	MVTL
4	9/6/23	10/26/23	**3.70**	MDH
4	10/3/23	10/12/23	**5.26**	MVTL
4	11/7/23	11/9/23	**4.59**	MVTL
4	12/5/23	12/7/23	**4.52**	MVTL
4	12/5/23	2/8/24	**4.60**	MDH
4	1/2/24	1/5/24	**3.88**	MVTL
4	2/13/24	2/22/24	**2.82**	MVTL
4	3/4/24	4/25/24	**2.80**	MDH
4	3/5/24	3/11/24	**2.95**	MVTL
4	4/2/24	4/3/24	**5.10**	MVTL
4	5/7/24	5/9/24	**2.63**	MVTL
4	6/4/24	6/20/24	**2.30**	MVTL
4	7/1/24	7/24/24	**5.10**	MDH
4	7/2/24	7/24/24	**3.26**	MVTL
4	8/6/24	8/14/24	**2.30**	MVTL
4	9/3/24	9/10/24	**2.26**	MVTL

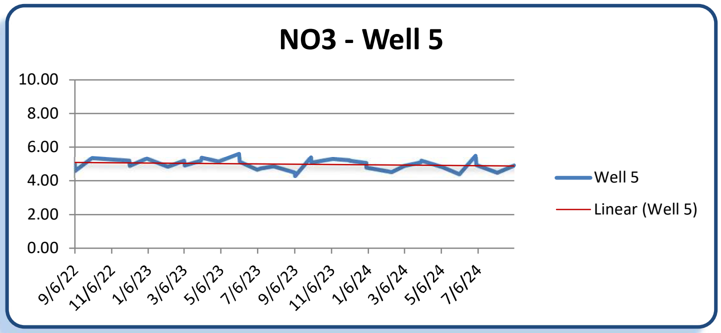


MVTL = Minnesota Valley Testing Laboratories
MDH = Minnesota Department of Health
TCWC = Twin City Water Clinic

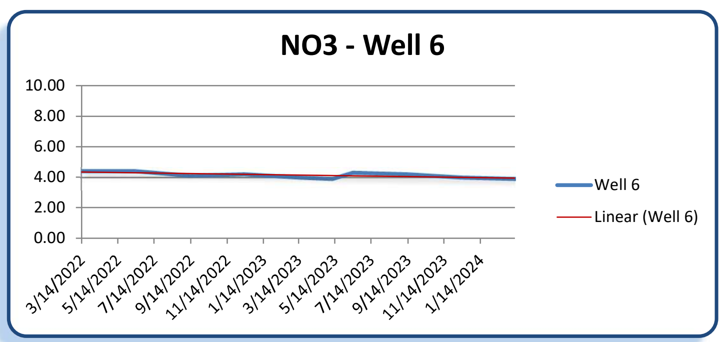
MN Department of Health
800-818-9318

Shakopee Public Utilities Commission
Water Department
Nitrate Results
Reported in mg/L

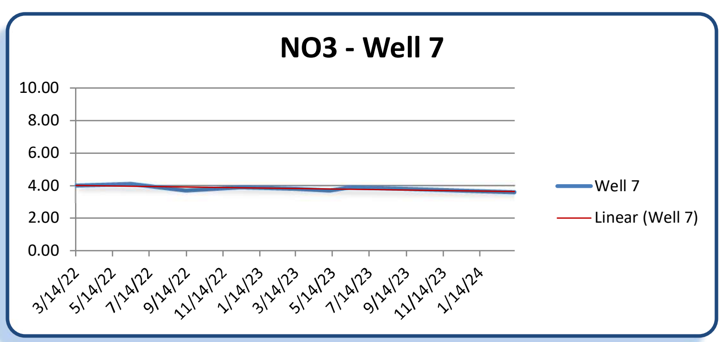
Location	Sample Collected	Results Received	Results	Lab
5	9/6/22	9/19/22	4.98	MVTL
5	9/6/22	10/25/22	4.60	MDH
5	10/4/22	10/11/22	5.35	MVTL
5	12/5/22	2/9/23	5.20	MDH
5	12/6/22	12/8/22	4.89	MVTL
5	1/3/23	3/10/23	5.32	MVTL
5	2/7/23	3/10/23	4.85	MVTL
5	3/6/23	4/6/23	5.20	MDH
5	3/7/23	3/10/23	4.92	MVTL
5	4/3/23	5/16/23	5.20	MDH
5	4/4/23	4/6/23	5.37	MVTL
5	5/2/23	5/5/23	5.15	MVTL
5	6/5/23	7/19/23	5.60	MDH
5	6/6/23	6/12/23	5.13	MVTL
5	7/5/23	7/19/23	4.67	MVTL
5	7/11/23	7/14/23	4.75	MVTL
5	8/1/23	8/7/23	4.87	MVTL
5	9/5/23	9/14/23	4.50	MVTL
5	9/6/23	10/26/23	4.30	MDH
5	10/2/23	11/2/23	5.40	MDH
5	10/3/23	10/12/23	5.08	MVTL
5	11/7/23	11/9/23	5.30	MVTL
5	12/5/23	12/7/23	5.22	MVTL
5	12/5/23	2/8/24	5.20	MDH
5	1/2/24	1/5/24	5.06	MVTL
5	1/2/24	2/8/24	4.80	MDH
5	2/13/24	2/22/24	4.53	MVTL
5	3/5/24	3/11/24	4.89	MVTL
5	4/1/24	4/25/24	5.10	MDH
5	4/2/24	4/3/24	5.19	MVTL
5	5/7/24	5/9/24	4.82	MVTL
5	6/4/24	6/20/24	4.41	MVTL
5	7/1/24	7/24/24	5.50	MDH
5	7/2/24	7/24/24	4.95	MVTL
5	8/6/24	8/14/24	4.49	MVTL
5	9/3/24	9/10/24	4.92	MVTL



6	3/14/2022	4/6/22	4.40	MDH
6	6/13/2022	7/11/22	4.40	MDH
6	9/12/2022	10/25/22	4.10	MDH
6	12/12/2022	2/9/23	4.20	MDH
6	3/13/2023	4/6/23	4.00	MDH
6	5/9/2023	5/16/23	3.90	MVTL
6	6/12/2023	7/19/23	4.30	MDH
6	9/11/2023	10/26/23	4.20	MDH
6	12/11/2023	2/8/24	4.00	MDH
6	3/11/2024	4/25/24	3.90	MDH



7	3/14/22	4/6/22	4.00	MDH
7	6/13/22	7/11/22	4.10	MDH
7	9/12/22	10/25/22	3.70	MDH
7	12/12/22	2/9/23	3.90	MDH
7	3/13/23	4/6/23	3.80	MDH
7	5/9/23	5/16/23	3.70	MVTL
7	6/12/23	7/19/23	3.90	MDH
7	9/11/23	10/26/23	3.80	MDH
7	12/11/23	2/8/24	3.70	MDH
7	3/11/24	4/25/24	3.60	MDH

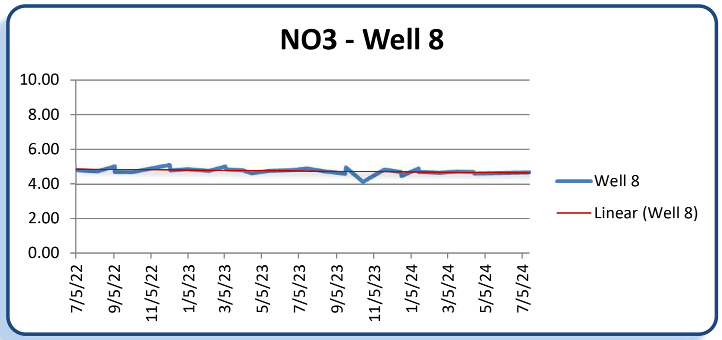


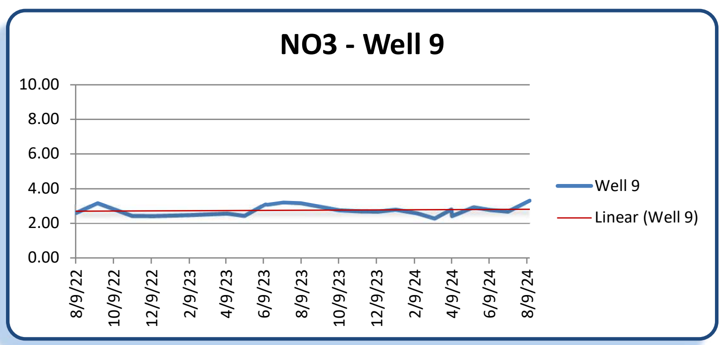
MVTL = Minnesota Valley Testing Laboratories
MDH = Minnesota Department of Health
TCWC = Twin City Water Clinic

MN Department of Health
800-818-9318

Shakopee Public Utilities Commission
Water Department
Nitrate Results
Reported in mg/L

Location	Sample Collected	Results Received		Results	Lab
8	7/5/22	7/18/22		**4.80**	MVTL
8	7/5/22	11/8/22		**4.80**	MDH
8	8/9/22	8/18/22		**4.74**	MVTL
8	9/6/22	9/19/22		**5.02**	MVTL
8	9/6/22	10/25/22		**4.70**	MDH
8	10/4/22	10/11/22		**4.69**	MVTL
8	12/5/22	2/9/23		**5.10**	MDH
8	12/6/22	12/8/22		**4.79**	MVTL
8	1/3/23	3/10/23		**4.86**	MVTL
8	2/7/23	3/10/23		**4.76**	MVTL
8	3/6/23	4/6/23		**5.00**	MDH
8	3/7/23	3/10/23		**4.85**	MVTL
8	4/3/23	5/16/23		**4.80**	MDH
8	4/18/23	5/4/23		**4.63**	MVTL
8	5/16/23	5/25/23		**4.76**	MVTL
8	6/21/23	9/27/23		**4.80**	MDH
8	7/18/23	7/20/23		**4.90**	MVTL
8	8/15/23	8/16/23		**4.74**	MVTL
8	9/18/23	10/26/23		**4.60**	MDH
8	9/19/23	9/27/23		**4.96**	MVTL
8	10/17/23	10/26/23		**4.14**	MVTL
8	11/21/23	12/7/23		**4.84**	MVTL
8	12/18/23	2/8/24		**4.70**	MDH
8	12/19/23	12/21/23		**4.47**	MVTL
8	1/16/24	1/24/24		**4.89**	MVTL
8	1/16/24	2/8/24		**4.70**	MDH
8	2/20/24	2/22/24		**4.65**	MVTL
8	3/19/24	3/25/24		**4.72**	MVTL
8	4/15/24	5/8/24		**4.70**	MDH
8	4/16/24	4/25/24		**4.61**	MVTL
8	7/16/24	7/24/24		**4.68**	MVTL
9	8/9/22	8/18/22		**2.60**	MVTL
9	9/13/22	9/21/22		**3.16**	MVTL
9	11/8/22	11/10/22		**2.44**	MVTL
9	12/13/22	12/14/22		**2.43**	MVTL
9	2/14/23	2/16/23		**2.49**	MVTL
9	4/11/23	10/4/23		**2.57**	MVTL
9	5/9/23	5/16/23		**2.44**	MVTL
9	6/12/23	7/19/23		**3.10**	MDH
9	6/15/23	6/22/23		**3.07**	MVTL
9	7/11/23	7/14/23		**3.21**	MVTL
9	8/8/23	8/10/23		**3.16**	MVTL
9	10/10/23	10/12/23		**2.76**	MVTL
9	11/14/23	11/20/23		**2.70**	MVTL
9	12/12/23	12/13/23		**2.68**	MVTL
9	1/9/24	1/24/24		**2.79**	MVTL
9	2/13/24	2/22/24		**2.58**	MVTL
9	3/12/24	3/14/24		**2.29**	MVTL
9	4/8/24	4/25/24		**2.80**	MDH
9	4/9/24	4/10/24		**2.43**	MVTL
9	5/14/24	5/29/24		**2.93**	MVTL
9	6/11/24	6/20/24		**2.77**	MVTL
9	7/9/24	8/14/24		**2.68**	MVTL
9	8/13/24	8/23/24		**3.31**	MVTL
10	4/17/12	4/20/12	<	**1.00**	TCWC
10	1/21/14	1/29/14	<	**1.00**	TCWC
10	3/25/14	4/1/14		**3.61**	MVTL
10	4/23/14	5/7/14	<	**0.20**	MVTL
10	4/23/14	6/16/14	<	**0.05**	MDH
10	6/16/15	6/26/15	<	**0.05**	MVTL
10	4/11/17	4/17/17	<	**0.05**	MVTL
10	1/8/19	1/14/19	<	**0.05**	MVTL
10	7/9/19	7/24/19	<	**0.05**	MVTL
10	10/12/21	10/20/21	<	**0.05**	MVTL
10	5/9/23	5/16/23	<	**0.05**	MVTL



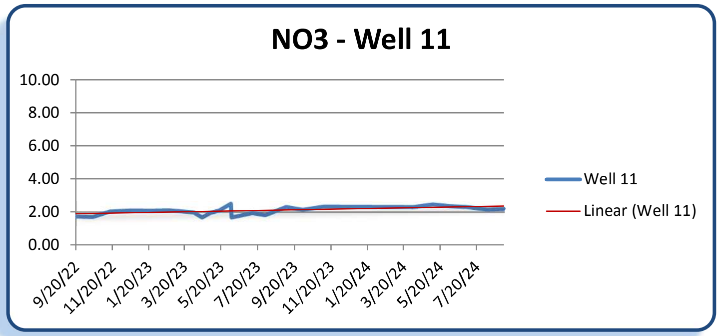


MVTL = Minnesota Valley Testing Laboratories
MDH = Minnesota Department of Health
TCWC = Twin City Water Clinic

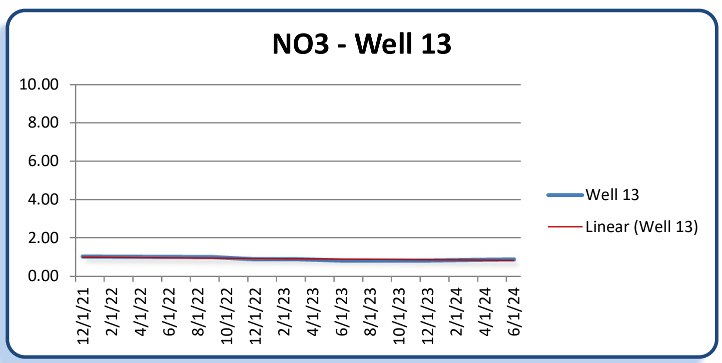
MN Department of Health
800-818-9318

Shakopee Public Utilities Commission
Water Department
Nitrate Results
Reported in mg/L

Location	Sample Collected	Results Received		Results	Lab
11	9/20/22	9/29/22		**1.74**	MVTL
11	10/18/22	10/21/22		**1.71**	MVTL
11	11/15/22	12/21/22		**2.04**	MVTL
11	12/20/22	12/21/22		**2.10**	MVTL
11	1/24/23	3/10/23		**2.08**	MVTL
11	2/21/23	2/28/23		**2.11**	MVTL
11	4/4/23	4/6/23		**1.98**	MVTL
11	4/18/23	5/4/23		**1.68**	MVTL
11	5/2/23	5/5/23		**1.96**	MVTL
11	5/16/23	5/25/23		**2.09**	MVTL
11	6/5/23	7/19/23		**2.50**	MDH
11	6/6/23	6/12/23		**1.68**	MVTL
11	7/11/23	7/14/23		**1.95**	MVTL
11	8/1/23	8/7/23		**1.82**	MVTL
11	9/5/23	9/14/23		**2.30**	MVTL
11	10/3/23	10/12/23		**2.14**	MVTL
11	11/7/23	11/9/23		**2.33**	MVTL
11	4/1/24	4/25/24		**2.30**	MDH
11	4/2/24	4/3/24		**2.29**	MVTL
11	5/7/24	5/9/24		**2.46**	MVTL
11	6/4/24	6/20/24		**2.36**	MVTL
11	7/2/24	7/24/24		**2.30**	MVTL
11	8/6/24	8/14/24		**2.15**	MVTL
11	9/3/24	9/10/24		**2.19**	MVTL



Location	Sample Collected	Results Received		Results	Lab
12	12/8/20	12/28/20		**0.69**	MVTL
12	3/9/21	3/23/21		**0.60**	MVTL
12	6/1/21	6/7/21		**0.57**	MVTL
12	9/14/21	9/29/21		**0.59**	MVTL
12	12/14/21	12/27/21		**0.50**	MVTL
12	3/23/22	4/6/22		**0.48**	MVTL
12	6/14/22	6/23/22		**0.49**	MVTL
12	9/13/22	9/21/22		**0.46**	MVTL
12	12/13/22	12/14/22		**0.46**	MVTL
13	12/7/21	12/15/21		**1.03**	MVTL
13	9/6/22	9/19/22		**1.00**	MVTL
13	12/6/22	12/8/22		**0.89**	MVTL
13	3/7/23	3/10/23		**0.89**	MVTL
13	6/6/23	6/12/23		**0.83**	MVTL
13	12/5/23	12/7/23		**0.83**	MVTL
13	3/5/24	3/11/24		**0.86**	MVTL
13	6/4/24	6/20/24		**0.88**	MVTL
14	4/23/14	6/16/14	<	**0.05**	MDH
14	4/11/17	4/17/17	<	**0.05**	MVTL
14	9/5/17	9/26/17	<	**0.05**	MVTL
14	12/5/17	12/22/17	<	**0.05**	MVTL
14	3/6/18	3/26/18	<	**0.05**	MVTL
14	6/5/18	6/14/18	<	**0.05**	MVTL



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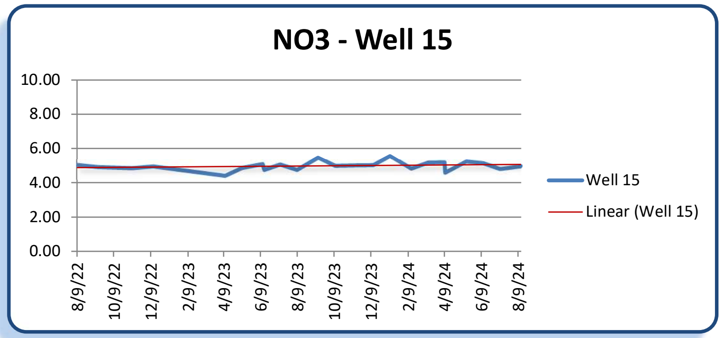
TCWC = Twin City Water Clinic

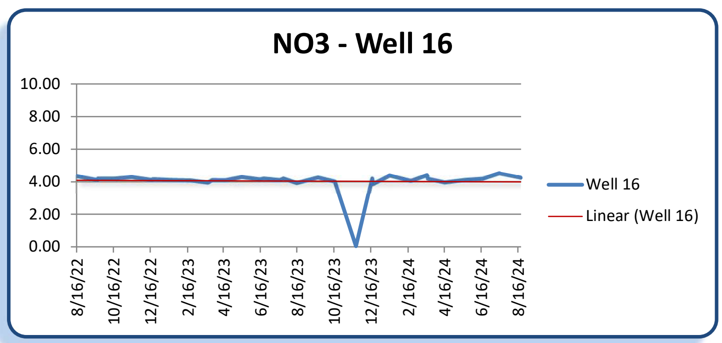
MN Department of Health
800-818-9318

Shakopee Public Utilities Commission
Water Department
Nitrate Results
Reported in mg/L

Location	Sample Collected	Results Received		Results	Lab
15	8/9/22	8/18/22		**5.05**	MVTL
15	9/13/22	9/21/22		**4.92**	MVTL
15	11/8/22	11/10/22		**4.86**	MVTL
15	12/13/22	12/14/22		**4.96**	MVTL
15	4/11/23	10/4/23		**4.43**	MVTL
15	5/9/23	5/16/23		**4.88**	MVTL
15	6/12/23	7/19/23		**5.10**	MDH
15	6/15/23	6/22/23		**4.77**	MVTL
15	7/11/23	7/14/23		**5.07**	MVTL
15	8/8/23	8/10/23		**4.77**	MVTL
15	9/12/23	9/14/23		**5.47**	MVTL
15	10/10/23	10/12/23		**5.00**	MVTL
15	11/14/23	11/20/23		**5.03**	MVTL
15	12/12/23	12/13/23	`	**5.04**	MVTL
15	1/9/24	1/24/24		**5.56**	MVTL
15	2/13/24	2/22/24		**4.84**	MVTL
15	3/12/24	3/14/24		**5.19**	MVTL
15	4/8/24	4/25/24		**5.20**	MDH
15	4/9/24	4/10/24		**4.60**	MVTL
15	5/14/24	5/29/24		**5.25**	MVTL
15	6/11/24	6/20/24		**5.15**	MVTL
15	7/9/24	8/14/24		**4.82**	MVTL
15	8/13/24	8/23/24		**4.97**	MVTL



Location	Sample Collected	Results Received		Results	Lab
16	8/16/22	8/30/22		**4.33**	MVTL
16	9/19/22	10/25/22		**4.10**	MDH
16	9/20/22	9/29/22		**4.19**	MVTL
16	10/18/22	10/21/22		**4.19**	MVTL
16	11/15/22	12/21/22		**4.28**	MVTL
16	12/19/22	4/6/23		**4.10**	MDH
16	12/20/22	12/21/22		**4.15**	MVTL
16	1/24/23	3/10/23		**4.10**	MVTL
16	2/21/23	2/28/23		**4.08**	MVTL
16	3/21/23	3/29/23		**3.95**	MVTL
16	3/28/23	6/13/23		**4.10**	MDH
16	4/18/23	5/4/23		**4.09**	MVTL
16	5/16/23	5/25/23		**4.28**	MVTL
16	6/15/23	6/22/23		**4.14**	MVTL
16	6/21/23	9/27/23		**4.20**	MDH
16	7/18/23	7/20/23		**4.10**	MVTL
16	7/24/23	8/10/23		**4.20**	MDH
16	8/15/23	8/16/23		**3.92**	MVTL
16	9/19/23	9/27/23		**4.26**	MVTL
16	10/17/23	10/26/23		**4.01**	MVTL
16	11/21/23	12/7/23	**<**	**0.05**	MVTL
16	12/18/23	2/8/24		**4.20**	MDH
16	12/19/23	12/21/23		**3.86**	MVTL
16	1/16/24	1/24/24		**4.37**	MVTL
16	2/20/24	2/22/24		**4.05**	MVTL
16	3/18/24	4/11/24		**4.40**	MDH
16	3/19/24	3/25/24		**4.18**	MVTL
16	4/16/24	4/25/24		**3.96**	MVTL
16	5/21/24	5/29/24		**4.11**	MVTL
16	6/18/24	6/26/24		**4.18**	MVTL
16	7/16/24	7/24/24		**4.52**	MVTL
16	7/16/24	8/14/24		**4.50**	MDH
16	8/20/24	8/28/24		**4.24**	MVTL




```
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```
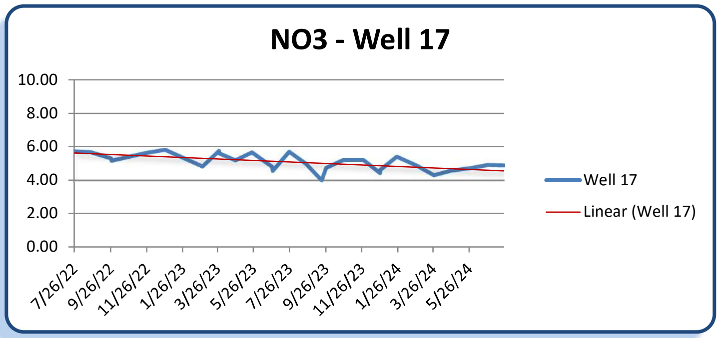
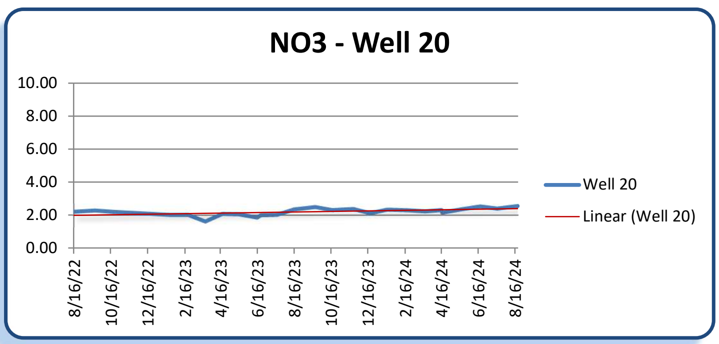

MN Department of Health
800-818-9318

Shakopee Public Utilities Commission
Water Department
Nitrate Results
Reported in mg/L

Location	Sample Collected	Results Received	Results	Lab
17	7/26/22	8/4/22	**5.71**	MVTL
17	8/23/22	9/9/22	**5.67**	MVTL
17	9/26/22	10/25/22	**5.30**	MDH
17	9/27/22	10/10/22	**5.16**	MVTL
17	11/22/22	3/10/23	**5.60**	MDH
17	12/27/22	2/24/23	**5.81**	MVTL
17	12/27/22	4/6/23	**5.80**	MDH
17	2/28/23	3/10/23	**4.82**	MVTL
17	3/28/23	4/4/23	**5.74**	MVTL
17	3/28/23	6/13/23	**5.60**	MDH
17	4/24/23	5/25/23	**5.20**	MDH
17	4/25/23	5/4/23	**5.18**	MVTL
17	5/23/23	6/7/23	**5.65**	MVTL
17	6/26/23	9/27/23	**4.80**	MDH
17	6/27/23	6/30/23	**4.55**	MVTL
17	7/25/23	7/31/23	**5.69**	MVTL
17	8/22/23	10/4/23	**4.98**	MVTL
17	9/18/23	10/26/23	**4.00**	MDH
17	9/25/23	10/26/23	**4.70**	MDH
17	9/26/23	10/4/23	**4.74**	MVTL
17	10/24/23	10/26/23	**5.20**	MVTL
17	11/28/23	12/7/23	**5.20**	MVTL
17	12/26/23	12/27/23	**4.42**	MVTL
17	12/26/23	2/8/24	**4.60**	MDH
17	1/23/24	1/29/24	**5.40**	MVTL
17	2/27/24	2/29/24	**4.85**	MVTL
17	3/26/24	4/1/24	**4.30**	MVTL
17	4/23/24	4/25/24	**4.57**	MVTL
17	5/28/24	6/10/24	**4.73**	MVTL
17	6/25/24	7/24/24	**4.91**	MVTL
17	7/23/24	8/14/24	**4.88**	MVTL



20	8/16/22	8/30/22	**2.20**	MVTL
20	9/20/22	9/29/22	**2.28**	MVTL
20	10/18/22	10/21/22	**2.20**	MVTL
20	1/24/23	3/10/23	**2.01**	MVTL
20	2/21/23	2/28/23	**2.01**	MVTL
20	3/21/23	3/29/23	**1.62**	MVTL
20	4/18/23	5/4/23	**2.08**	MVTL
20	5/16/23	5/25/23	**2.05**	MVTL
20	6/15/23	6/22/23	**1.86**	MVTL
20	6/21/23	7/19/23	**2.00**	MDH
20	7/18/23	7/20/23	**2.03**	MVTL
20	8/15/23	8/16/23	**2.34**	MVTL
20	9/19/23	9/27/23	**2.49**	MVTL
20	10/17/23	10/26/23	**2.30**	MVTL
20	11/21/23	12/7/23	**2.37**	MVTL
20	12/19/23	12/21/23	**2.12**	MVTL
20	1/16/24	1/24/24	**2.33**	MVTL
20	2/20/24	2/22/24	**2.29**	MVTL
20	3/19/24	3/25/24	**2.23**	MVTL
20	4/15/24	5/8/24	**2.30**	MDH
20	4/16/24	4/25/24	**2.15**	MVTL
20	5/21/24	5/29/24	**2.37**	MVTL
20	6/18/24	6/26/24	**2.52**	MVTL
20	7/16/24	7/24/24	**2.39**	MVTL
20	8/20/24	8/28/24	**2.55**	MVTL



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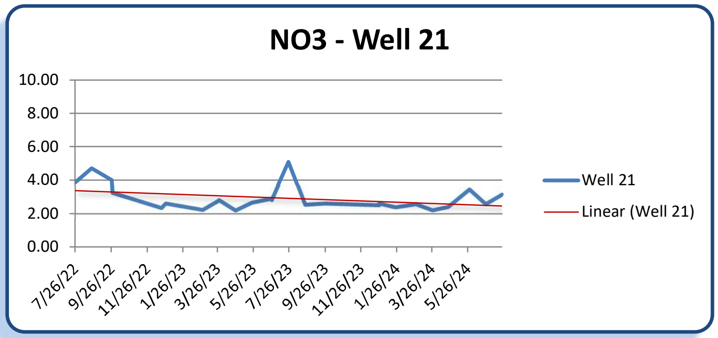
MN Department of Health
800-818-9318

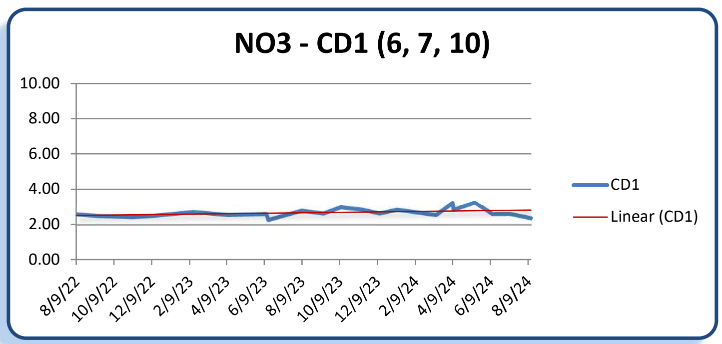
Shakopee Public Utilities Commission
Water Department
Nitrate Results
Reported in mg/L

Location	Sample Collected	Results Received	Results	Lab
21	7/26/22	8/4/22	3.87	MVTL
21	8/23/22	9/9/22	4.70	MVTL
21	9/26/22	10/25/22	4.00	MDH
21	9/27/22	10/6/22	3.24	MVTL
21	12/20/22	12/21/22	2.34	MVTL
21	12/27/22	4/6/23	2.60	MDH
21	2/28/23	3/10/23	2.23	MVTL
21	3/28/23	4/4/23	2.78	MVTL
21	3/28/23	6/13/23	2.80	MDH
21	4/25/23	5/4/23	2.19	MVTL
21	5/23/23	6/7/23	2.66	MVTL
21	6/26/23	7/19/23	2.90	MDH
21	6/26/23	9/27/23	2.80	MDH
21	6/27/23	6/30/23	2.91	MVTL
21	7/25/23	7/31/23	5.09	MVTL
21	8/22/23	10/3/23	2.53	MVTL
21	9/25/23	10/26/23	2.60	MDH
21	9/26/23	10/3/23	2.60	MVTL
21	12/26/23	12/27/23	2.50	MVTL
21	12/26/23	2/8/24	2.60	MDH
21	1/23/24	1/29/24	2.38	MVTL
21	2/27/24	2/29/24	2.57	MVTL
21	3/26/24	4/1/24	2.20	MVTL
21	4/22/24	5/8/24	2.40	MDH
21	4/23/24	4/25/24	2.44	MVTL
21	5/28/24	6/10/24	3.44	MVTL
21	6/25/24	7/24/24	2.56	MVTL
21	7/23/24	8/14/24	3.14	MVTL



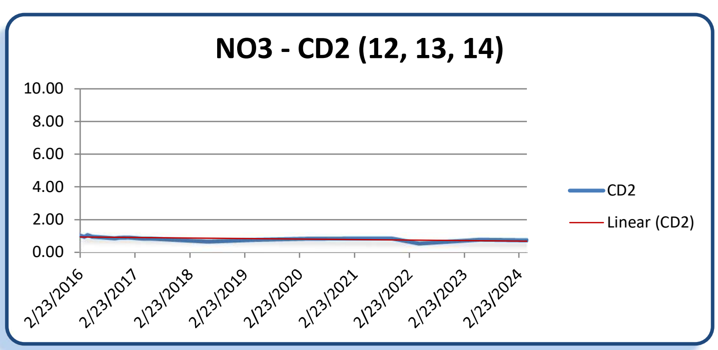
Combined Discharge - Wells 6-7-10

CD 1	8/9/22	8/18/22	2.57	MVTL
CD 1	9/13/22	9/21/22	2.49	MVTL
CD 1	11/8/22	11/10/22	2.42	MVTL
CD 1	12/13/22	12/14/22	2.50	MVTL
CD 1	2/14/23	2/16/23	2.70	MVTL
CD 1	4/11/23	10/4/23	2.54	MVTL
CD 1	6/12/23	7/19/23	2.60	MDH
CD 1	6/15/23	6/22/23	2.26	MVTL
CD 1	7/11/23	7/14/23	2.51	MVTL
CD 1	8/8/23	8/10/23	2.78	MVTL
CD 1	9/12/23	9/14/23	2.62	MVTL
CD 1	10/10/23	10/12/23	2.97	MVTL
CD 1	11/14/23	11/20/23	2.83	MVTL
CD 1	12/12/23	12/13/23	2.62	MVTL
CD 1	1/9/24	1/24/24	2.83	MVTL
CD 1	3/12/24	3/14/24	2.54	MVTL
CD 1	4/8/24	4/25/24	3.20	MDH
CD 1	4/9/24	4/10/24	2.82	MVTL
CD 1	5/14/24	5/29/24	3.23	MVTL
CD 1	6/11/24	6/20/24	2.60	MVTL
CD 1	7/9/24	8/14/24	2.61	MVTL
CD 1	8/13/24	8/23/24	2.35	MVTL



Combined Discharge - Wells 12-13-14

CD 2	2/23/2016	2/29/2016	1.03	MVTL
CD 2	3/22/2016	3/28/2016	0.96	MVTL
CD 2	4/12/2016	4/19/2016	1.07	MVTL
CD 2	5/10/2016	5/16/2016	0.98	MVTL
CD 2	5/10/2016	6/2/2016	0.97	MDH
CD 2	7/12/2016	7/18/2016	0.93	MVTL
CD 2	10/11/2016	10/17/2016	0.87	MVTL
CD 2	11/8/2016	11/17/2016	0.91	MVTL
CD 2	1/10/2017	1/20/2017	0.92	MVTL
CD 2	4/11/2017	4/17/2017	0.85	MVTL
CD 2	6/8/2017	6/28/2017	0.86	MDH
CD 2	6/22/2018	7/18/2018	0.67	MDH
CD 2	4/16/2019	5/1/2019	0.78	MDH
CD 2	4/27/2020	6/5/2020	0.86	MDH
CD 2	10/25/2021	11/15/2021	0.87	MDH
CD 2	4/25/2022	5/23/2022	0.56	MDH
CD 2	6/5/2023	7/19/2023	0.79	MDH
CD 2	4/15/2024	5/8/2024	0.75	MDH



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RESOLUTION #2024-29

RESOLUTION APPROVING PAYMENT FOR THE PIPE OVERSIZING COSTS ON THE WATERMAIN PROJECT:

HIGHVIEW PARK 1ST ADDITION

WHEREAS, the Shakopee Public Utilities Commission had previously approved of an estimated amount of $265,378.95 with Resolution #2023-24 for oversizing on the above described watermain project, and

WHEREAS, the pipe sizes required for that project have been installed as shown on the engineering drawing by Kimley-Horn & Associates, and

WHEREAS, a part, or all, of the project contains pipe sizes larger than would be required under the current Standard Watermain Design Criteria as adopted by the Shakopee Public Utilities Commission, and

WHEREAS, the policy of the Shakopee Public Utilities Commission calls for the payment of these costs to install oversize pipe above the standard size.

NOW THEREFORE, BE IT RESOLVED, that the payment by the Shakopee Public Utilities Commission for the oversizing on this project is approved in the amount of $209,306.82, and

BE IT FURTHER RESOLVED, that all things necessary to carry out the terms and purpose of this Resolution are hereby authorized and performed.

Passed in regular session of the Shakopee Public Utilities Commission, this 7th day of October, 2024.

____

Vice President: BJ Letourneau

ATTEST:

____

Commission Secretary: Greg Drent

Proposed As Consent Item **3h**

SPU
Shakopee Public Utilities

PO Box 470 • 255 Sarazin Street
Shakopee, Minnesota 55379
Main 952.445-1988 • Fax 952.445-7767
www.shakopeeutilities.com

DATE: October 3, 2024

TO: Greg Drent, General Manager

FROM: Kelley Willemssen, Director of Finance & Administration

SUBJECT: August 31, 2024 – Financials Reports

As part of the August 31, 2024, financial reports we continued the practice of providing a component of analytical review. For the Water and Electric Operating Revenue and Expense budget to actual reports you will see comments at the bottom of each page. In addition to the analytical review, there are a few important points to note.

- The budget is projected on an annual basis rather than a monthly basis, so the information reported through August 31,2024, equates to 67% of the annual budget.
- Change in net position for the electric division as of 08/31/2024 is favorable at $3.5M.
- Change in net position for the water division as of 08/31/2024 is favorable at $3.8M.
- YTD electric operating revenues are down 2.6% from the prior year.
- YTD electric operating revenues are down 5.1% from budget due to less KWH usage than projected through August and the even budget spread for the full year.
- YTD electric expenses are down 7.5% (excluding depreciation) from the previous year. Depreciation for the electric division is higher due to the accelerated depreciation adjustment made for the retirement of old meters through the AMI project.
- YTD electric expenses are better (excluding depreciation) to budget mainly due to less purchase power costs through August.
- YTD water operating revenues are down 16.0% from the prior year.
- YTD water operating revenues are down 10.9% from budget due to less water usage than projected through August and the even budget spread for the full year.
- YTD water expenses are within 1% (excluding depreciation) of the previous year expenses. Depreciation for the water division is higher due to the accelerated depreciation adjustment made for the retirement of old meters through the AMI project.
- YTD water expenses are better to (excluding depreciation) to budget by 13.1%.

Included in this report are the following statements:
- Combined Statement of Revenues, Expenses and Changes in Fund Net Position
- Electric Operating Revenue and Expense – Budget to Actual (with analytics)
- Water Operating Revenue and Expense– Budget to Actual (with analytics)
- Electric Operating Revenue and Expense – 2023 to 2024
- Water Operating Revenue and Expense – 2023 to 2024

Request
The Commission is requested to accept the Financial Reports for the period ending 08/31/2024.

SHAKOPEE PUBLIC UTILITIES
COMBINED STATEMENT OF REVENUES, EXPENSES AND CHANGES IN FUND NET POSITION

	Year to Date Actual - August 31, 2024			Year to Date Budget - August 31, 2024			Electric YTD Actual v. Budget B/(W)		Water YTD Actual v. Budget B/(W)		Total Utility YTD Actual v. Budget B/(W)	
	Electric	Water	Total Utility	Electric	Water	Total Utility	$	%	$	%	$	%
OPERATING REVENUES	$ 38,851,492	4,214,374	43,065,866	40,930,642	4,732,367	45,663,008	(2,079,149)	-5.1%	(517,993)	-10.9%	(2,597,142)	-5.7%
OPERATING EXPENSES						-						
Operation, Customer and Administrative	32,334,537	2,778,153	35,112,690	35,524,797	3,196,481	38,721,278	3,190,260	9.0%	418,328	13.1%	3,608,588	9.3%
Depreciation	2,624,551	1,926,873	4,551,424	2,174,647	1,337,851	3,512,497	(449,905)	-20.7%	(589,022)	-44.0%	(1,038,927)	-29.6%
Total Operating Expenses	34,959,089	4,705,026	39,664,115	37,699,444	4,534,331	42,233,775	2,740,355	7.3%	(170,694)	-3.8%	2,569,661	6.1%
Operating Income	3,892,402	(490,652)	3,401,751	3,231,198	198,036	3,429,234	661,205	20.5%	(688,688)	347.8%	(27,484)	-0.8%
NON-OPERATING REVENUE (EXPENSE)												
Rental and Miscellaneous	384,499	523,692	908,191	160,199	72,539	232,738	224,301	140.0%	451,153	621.9%	675,453	290.2%
Interdepartment Rent from Water	60,000	-	60,000	60,000	-	60,000	-	0.0%	-	0.0%	-	0.0%
Investment Income	1,443,002	1,034,394	2,477,396	679,103	324,777	1,003,881	763,899	112.5%	709,617	218.5%	1,473,516	146.8%
Interest Expense	(58,546)	(3,227)	(61,772)	(52,655)	(8,000)	(60,655)	(5,891)	-11.2%	4,773	59.7%	(1,118)	-1.8%
Gain/(Loss) on the Disposition of Property	8,663	12,765	21,428	-		-	8,663	0.0%	12,765	-	21,428	-
Total Non-Operating Revenue (Expense)	1,837,619	1,567,624	3,405,243	846,647	389,317	1,235,964	990,972	117.0%	1,178,308	302.7%	2,169,279	175.5%
Income Before Contributions and Transfers	5,730,022	1,076,972	6,806,994	4,077,845	587,353	4,665,198	1,652,176	40.5%	489,619	83.4%	2,141,796	45.9%
CAPITAL CONTRIBUTIONS	288,065	3,089,289	3,377,354	487,108	2,433,274	2,920,382	(199,043)	40.9%	656,015	27.0%	456,972	15.6%
MUNICIPAL CONTRIBUTION	(2,519,306)	(283,936)	(2,803,242)	(2,423,260)	(283,942)	(2,707,202)	(96,046)	-4.0%	6.00	0.0%	(96,040)	-3.5%
CHANGE IN NET POSITION	$ 3,498,781	3,882,325	7,381,106	2,141,692	2,736,684	4,878,376	1,357,089	63.4%	1,145,641	41.9%	2,502,730	51.3%

SHAKOPEE PUBLIC UTILITIES
ELECTRIC OPERATING REVENUE AND EXPENSE
For period ending August 31, 2024

	YTD Actual 8/31/2024	YTD Budget 8/31/2024	YTD Actual v. Budget Increase (decrease) $	%	
OPERATING REVENUES					
Sales of Electricity					
Residential	$ 14,145,434	15,544,150	(1,398,716)	91.0	
Commercial and Industrial	23,882,761	24,493,932	(611,171)	97.5	
Total Sales of Electricity	38,028,194	40,038,082	(2,009,887)	95.0	
Forfeited Discounts	161,269	203,746	(42,477)	79.2	(1)
Free service to the City of Shakopee	96,042	88,243	7,799	108.8	
Conservation program	565,987	600,571	(34,584)	94.2	
Total Operating Revenues	38,851,492	40,930,642	(2,079,149)	94.9	
OPERATING EXPENSES					
Operations and Maintenance					
Purchased power	27,326,955	29,171,708	(1,844,753)	93.7	
Distribution operation expenses	390,783	593,637	(202,854)	65.8	(2)
Distribution system maintenance	638,184	825,550	(187,366)	77.3	(3)
Maintenance of general plant	377,712	258,481	119,232	146.1	(4)
Total Operation and Maintenance	28,733,635	30,849,376	(2,115,742)	93.1	
Customer Accounts					
Meter Reading	97,449	100,498	(3,049)	97.0	
Customer records and collection	395,569	643,785	(248,216)	61.4	(5)
Energy conservation	156,416	607,592	(451,176)	25.7	(6)
Total Customer Accounts	649,434	1,351,875	(702,441)	48.0	
Administrative and General					
Administrative and general salaries	576,167	758,931	(182,765)	75.9	(7)
Office supplies and expense	347,406	368,061	(20,655)	94.4	
Outside services employed	280,513	383,751	(103,238)	73.1	(8)
Insurance	123,862	116,667	7,195	106.2	
Employee Benefits	1,280,329	1,242,514	37,815	103.0	
Miscellaneous general	343,191	453,621	(110,430)	75.7	(9)
Total Administrative and General	2,951,469	3,323,546	(372,077)	88.8	
Total Operation, Customer, & Admin Expenses	32,334,537	35,524,797	(3,190,260)	91.0	
Depreciation	2,624,551	2,174,647	449,905	120.7	
Total Operating Expenses	$ 34,959,089	37,699,444	(2,740,355)	92.7	
Operating Income	$ 3,892,403	3,231,198	661,206	120.5	

Item Explanation of Items Percentage Received/Expended Less than 80% or Greater than 120% and $ Variance Greater than $15,000.

(1) YTD budget variance in penalty revenue is down from budget. Collection reports are showing less penalities and disconnects since additional notification options are available through SmartHub.
(2) YTD budget variance in distribution operating expenses is better than budgeted, labor and expenses have shifted to maintenance, AMI, and construction projects.
(3) YTD budget variance in distribution system maintenance expenses is better than budgeted, labor and expenses have shifted to maintenance of general, AMI, and construction projects.
(4) YTD budget variance in maintenance of general plant is higher than budgeted due to more labor and expenses being booked. Overall, operations and maintenance is still better to budget YTD.
(5) YTD budget variance is due to lower credit card and collection expenses budgeted. New credt card rates through SmartHub is the factor contributing to this variance.
(6) YTD budget variance is mainly due to timing of rebates and the budget having an even spread. Should stabalize throughout the year.
(7) YTD budget variance is due to 2024 budget including two full time positions currently unfilled.
(8) YTD budget variance is due to outside services that are not completed yet.
(9) YTD budget variance is due to lower than projected miscellaneous labor and material actuals through August.

SHAKOPEE PUBLIC UTILITIES
WATER OPERATING REVENUE AND EXPENSE
For period ending August 31, 2024

		YTD Actual 8/31/2024	YTD Budget 8/31/2024	YTD Actual v. Budget Increase (decrease) $	%	
OPERATING REVENUES						
Sales of Water	$	4,201,843	4,705,768	(503,925)	89.3	
Forfeited Discounts		12,531	26,599	(14,068)	47.1	
Total Operating Revenues		4,214,374	4,732,367	(517,993)	89.1	
OPERATING EXPENSES						
Operations and Maintenance						
Pumping and distribution operation		490,571	552,066	(61,495)	88.9	
Pumping and distribution maintenance		426,763	489,014	(62,251)	87.3	
Power for pumping		268,104	290,086	(21,982)	92.4	
Maintenance of general plant		43,320	46,605	(3,284)	93.0	
Total Operation and Maintenance		1,228,758	1,377,771	(149,012)	89.2	
Customer Accounts						
Meter Reading		46,957	47,535	(578)	98.8	
Customer records and collection		116,188	163,440	(47,252)	71.1	(1)
Total Customer Accounts		165,337	210,975	(45,638)	78.4	
Administrative and General						
Administrative and general salaries		335,883	452,117	(116,234)	74.3	(2)
Office supplies and expense		116,709	91,605	25,105	127.4	(3)
Outside services employed		145,435	245,297	(99,862)	59.3	(4)
Insurance		41,317	30,075	11,242	137.4	(5)
Employee Benefits		599,835	603,713	(3,878)	99.4	
Miscellaneous general		144,879	184,929	(40,050)	78.3	(6)
Total Administrative and General		1,384,058	1,607,735	(223,677)	86.1	
Total Operation, Customer, & Admin Expenses		2,778,153	3,196,481	(418,328)	86.9	
Depreciation		1,926,873	1,337,851	589,022	144.0	(7)
Total Operating Expenses	$	4,705,026	4,534,331	170,694	103.8	
Operating Income	$	(490,652)	198,035	(688,687)	(247.8)	

Item	Explanation of Items Percentage Received/Expended Less than 80% or Greater than 120% and $ Variance Greater than $15,000.
(1)	YTD budget variance is due to lower credit card and collection expenses budgeted. New credt card rates through SmartHub is the factor contributing to this variance.
(2)	YTD budget variance is due to 2024 budget including two full time positions currently unfilled.
(3)	YTD budget variance is due to higher than projected office expenses through August, should stabalize throughout the year.
(4)	YTD budget variance is due to outside services that are not completed yet.
(5)	YTD budget variance is due to timing of when insurance is paid. Should stabalize throughout the year.
(6)	YTD budget variance is due to lower than projected miscellaneous labor and material actuals through August.
(7)	The 2024 depreciation budget did not include the accelerated depreciation adjustment for the AMI project. $523K was not budgeted and is causing the higher variance.

SHAKOPEE PUBLIC UTILITIES
ELECTRIC OPERATING REVENUE AND EXPENSE
For period ending August 31, 2024

		2024	2023	2023-2024 Increase (decrease) $	%
OPERATING REVENUES					
Residential	$	14,145,434	14,495,211	(349,777)	97.6
Commercial and Industrial		23,882,761	24,499,207	(616,446)	97.5
Total Sales of Electricity		38,028,194	38,994,418	(966,224)	97.5
Forfeited Discounts		161,269	221,478	(60,209)	72.8
Free service to the City of Shakopee		96,042	80,561	15,481	119.2
Conservation program		565,987	581,718	(15,731)	97.3
Total Operating Revenues		38,851,492	39,878,175	(1,026,683)	97.4
OPERATING EXPENSES					
Purchased power		27,326,955	29,815,568	(2,488,613)	91.7
Distribution operation expenses		390,783	465,670	(74,887)	83.9
Distribution system maintenance		638,184	787,468	(149,284)	81.0
Maintenance of general plant		377,712	160,341	217,371	235.6
Total Operation and Maintenance		28,733,635	31,229,047	(2,495,412)	92.0
Meter Reading		97,449	90,412	7,037	107.8
Customer records and collection		395,569	502,893	(107,324)	78.7
Energy conservation		156,416	276,970	(120,554)	56.5
Total Customer Accounts		649,434	870,275	(220,841)	74.6
Administrative and general salaries		576,167	519,074	57,093	111.0
Office supplies and expense		347,406	330,146	17,260	105.2
Outside services employed		280,513	293,731	(13,218)	95.5
Insurance		123,862	87,747	36,115	141.2
Employee Benefits		1,280,329	1,315,070	(34,741)	97.4
Miscellaneous general		343,191	322,994	20,197	106.3
Total Administrative and General		2,951,469	2,868,762	82,707	102.9
Total Operating Expenses		32,334,537	34,968,084	(2,633,547)	92.5
Depreciation		2,624,551	1,864,066	760,485	140.8
Total Operating Expenses	$	34,959,089	36,832,150	(1,873,061)	94.9
Operating Income	$	3,892,403	3,046,025	846,378	127.8

SHAKOPEE PUBLIC UTILITIES
WATER OPERATING REVENUE AND EXPENSE
For period ending August 31, 2024

		2024	2023	2023-2024 Increase (decrease) $	%
OPERATING REVENUES	$				
Sales of Water		4,201,843	5,002,697	(800,854)	84.0
Forfeited Discounts		12,531	15,714	(3,183)	79.7
Total Operating Revenues		4,214,374	5,018,410	(804,036)	84.0
OPERATING EXPENSES					
Operations and Maintenance					
Pumping and distribution operation		490,571	581,408	(90,837)	84.4
Pumping and distribution maintenance		426,763	361,385	65,378	118.1
Power for pumping		268,104	243,450	24,654	110.1
Maintenance of general plant		43,320	48,715	(5,395)	88.9
Total Operation and Maintenance		1,228,758	1,234,958	(6,200)	99.5
Customer Accounts					
Meter Reading		46,957	61,719	(14,762)	76.1
Customer records and collection		116,188	158,126	(41,938)	73.5
Energy conservation		2,192	380	1,812	576.8
Total Customer Accounts		165,337	220,225	(54,888)	75.1
Administrative and General					
Administrative and general salaries		335,883	315,456	20,427	106.5
Office supplies and expense		116,709	103,797	12,912	112.4
Outside services employed		145,435	142,446	2,989	102.1
Insurance		41,317	37,141	4,176	111.2
Employee Benefits		599,835	597,313	2,521	100.4
Miscellaneous general		144,879	120,358	24,520	120.4
Total Administrative and General		1,384,058	1,316,511	67,547	105.1
Total Operating Expenses		2,778,153	2,771,694	6,459	100.2
Depreciation		1,926,873	1,279,572	647,301	150.6
Total Operating Expenses		4,705,026	4,051,266	653,760	116.1
Operating Income	$	(490,652)	967,145	(1,457,797)	(50.7)

Proposed As Consent Item

3i

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To: SPU Commissioners

From: Greg Drent, General Manager

Date: October 3, 2024

Subject: MMPA September 2024 Meeting Update

The Board of Directors of the Minnesota Municipal Power Agency (MMPA) met on September 24, 2024, at Chaska City Hall in Chaska, Minnesota and via videoconference.

The Board reviewed the Agency's operating and financial performance for August 2024.

Clean Energy Choice program participation increased to 5.8%.

The Board discussed the status of renewable projects the Agency is pursuing.

6b

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October 2, 2024

TO: Greg Drent, General Manager

FROM: Sharon Walsh, Director of Marketing, Key Accounts and Special Projects

SUBJECT: Backflow Penalty Appeal and Resolution – Mr. Mikhail Stalmakov

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Overview

On billing statement dated July 22, 2024, Mr. Stalmakov received a $150 penalty under the terms of the Backflow Penalty Schedule that was approved by SPU Commissioners at the May 6, 2024 meeting. (See attached schedule and communications.) He initiated an appeal that Mr. Drent responded to on August 8, 2024, response also attached. In disagreement with that response, Mr. Stalmakov requested to be on the agenda at the next commission meeting.

At the September 9, 2024 Commission meeting, Mr. Stalmakov stated that the plumbing code applied to fire sprinkler systems, not garden sprinkler systems. He also indicated there was no way for water to backflow to the water system. And lastly, he noted that he was exempt from the policy because his system was installed prior to 2016, making reference to the MN Dept of Labor and Industry "Fact Sheet: Backflow Devices, 2020 Minnesota Plumbing Code" versus Minnesota Admin. Rule 4714.0603 and SPU's Backflow Prevention and Cross-Connection Control Policy (https://shakopeeutilities.com/wp-content/uploads/2022/08/Backflow-Prevention-and-Cross-Connection-Control-Policy.pdf), in which no irrigation system is exempt from testing based on installation date.[1]

At the conclusion of Mr. Stalmakov's appeal to the Commission, staff was directed to further clarify the risk of backflow to the water distribution system and/or customer taps and confirm the applicable prevailing codes. These findings would be presented at a future Commission meeting.

Per Commission direction, attached are documents produced by the federal Environmental Protection Agency (EPA) citing incidents of contamination, including E. coli, parasitic worms and other waterborne disease outbreaks from non-protected systems. When testing backflow devices SPU found an average failure rate of 33.9% - 1 in 3 systems on SPU's distributed system were not protected. In 2023, 87 systems failed out of 231 systems tested. In 2024, 103 systems failed out of 341 systems tested. The City of Shakopee has adopted the 2020 MN Plumbing Code and expressed support of SPU's backflow prevention efforts.

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[1] It should be noted that although SPU initially included a MN Department of Labor and Industry factsheet on its website, given the confusion and conflict with the 2020 Plumbing Code and administrative rule, it has been removed.

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The Commission also asked staff to consider federal law.[2] The federal Safe Drinking Water Act established a framework for regulating contaminants in public water systems. Under the Act, states have primary responsibility for public water systems. 42 U.S.C. § 300g-2(a); § 300f (defining public water system); § 300g-3 (requiring owner or operator of public water system to provide notice if violation of standards). In 1977, Minnesota enacted the Safe Drinking Water Act. Minn. Stat. §§ 144.381 – 144.387. The State adopted the federal definition of public water systems (Minn. Stat. §144.382, subd. 4) and defined a water supplier as one "who owns, manages or operates a public water supply." Minn. Stat. §144.382, subd. 5.

As the water purveyor who manages and operates a public water system, SPU follows not only the most current MN Plumbing Code, but also state administrative rules (Minn. Admin. R. 4714.0603, 4720.0025). None of these documents cite an installation date for testing parameters. Instead, they indicate a minimum of testing schedule of "annual."

In addition, and of significant importance, are the manufacturers' maintenance and inspection requirements of their backflow devices, citing "annual inspection" or "at least once per year or more". Examples attached.

Lastly, Mr. Stalmakov had the option of avoiding a $150 backflow penalty by requesting a lock-out of his system until such time he was interested in running his irrigation system. SPU would perform the lockout at no cost to Mr. Stalmakov. This action would have made Mr. Stalmakov compliant with the policy.

Action Requested

Staff recommends denial of Mr. Stalmakov's appeal to remove the $150 backflow penalty for failure to comply with SPU's Backflow Prevention and Cross-Connection Control Policy and approval of Resolution 2024-30, A Resolution Making Findings of Fact and Determining the Appeal Submitted by Mikhail Stalmakov.

[2] Although there was reference made to the Clean Water Act, the applicable federal legislation is the Safe Drinking Water Act.

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DATE: May 2, 2024

TO: Greg Drent, General Manager

FROM: Lon Schemel, Water Superintendent

Subject: Backflow testing and penalty schedule

I thought I would take a step back and remind everyone the importance and commitment to backflow testing and policy. Backflow occurs when the flow of water reverses direction, potentially causing contaminated water to enter the clean water supply. This poses serious health risks to consumers and can lead to regulatory violations, fines, and damage to our reputation.

Here are some key points to remember about backflow prevention:

1. **Health and Safety:** Backflow can introduce harmful substances such as chemicals, bacteria, and other contaminants into our drinking water. These contaminants can pose serious health risks, especially to vulnerable populations such as children, the elderly, and individuals with compromised immune systems.
2. **Regulatory Compliance:** Compliance with backflow prevention regulations is not optional—it is mandatory. It is essential that we adhere to all relevant regulations and standards to protect public health and safety.
3. **Protecting all Customers:** Our commitment to providing safe, clean drinking water to all customers is central to our reputation as a trusted provider. Any incidents of backflow contamination can damage the trust and confidence that our customers have in us. By prioritizing backflow prevention, we demonstrate our dedication to upholding the highest standards of quality and safety.
4. **Responsibility of All Employees:** Backflow prevention is not solely the responsibility of a single department or individual. It requires the collective effort of all employees and board of directors to identify potential risks, implement appropriate prevention measures, and respond effectively to any incidents that may arise. We must remain vigilant and proactive in our efforts to safeguard the integrity of our water supply.

In conclusion, backflow prevention is a critical aspect of our operations that cannot be overlooked. By prioritizing backflow prevention measures, we protect public health,

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ensure regulatory compliance, and uphold our reputation as a trusted provider of clean drinking water.

Attached is the backflow penalty schedule that we discussed at previous commission meetings and guidelines you recommended.

SPU will be working with the City of Shakopee in the upcoming months to continue to strengthen our position on backflow preventions and regulations.

Action: **Approve Backflow Penalty Schedule**

Backflow Penalty Schedule

I. Commercial Annual Inspection:

1. The Compliance Engine will send reminders via mail or email to commercial or industrial customers approximately 30 days before the annual due date for testing their backflow preventer assembly.
2. It is the owners' responsibility to contact an ASSE Certified Backflow Tester to have their assembly(s) tested by the annual due date.
3. The tester must submit the test results to SPU via The Compliance Engine within 30 days of the test.
4. If an assembly is not tested within 45 days of the annual due date, the Compliance Engine will send a deficiency notice to the owner.
5. A testing penalty of $150.00 will be imposed if test results are not received within 60 days after the annual testing due date of the assembly.
6. The testing penalty will be refunded with a successful test submission to The Compliance Engine within 30 days of the penalty date.
7. If the backflow preventer test fails, the owner must repair and/or replace the device within 30 days. A repair penalty of $150.00 will be imposed if a failed backflow preventer is not repaired and/or if passing test results are not submitted to SPU via The Compliance Engine within that timeframe.
8. The repair penalty will be refunded with a successful test submission to The Compliance Engine within 30 days of the penalty date.
9. SPU may discontinue water service at any time if a backflow assembly is not tested or if a hazard exists to the municipal water system.

II. Residential Annual Inspection:

1. SPU via The Compliance Engine will send reminders via mail or email to residential customers approximately 30 days before the annual testing due date for testing their backflow preventer assembly.
2. Customers must contact an ASSE Certified Backflow Assembly Tester to have their backflow assembly tested before their annual testing due date.
3. The tester must submit the test results to SPU via The Compliance Engine within 30 days of the test.
4. If an assembly is not tested and submitted within the month of their due date, it is considered delinquent, and The Compliance Engine will send a delinquency notice to the owner. (This notice will indicate a testing penalty will be applied to their utility account and the irrigation system is scheduled for Lock-Out.)

5. For delinquent accounts, a one-time testing penalty of $150 will be imposed on the following month's billing statement if test results are not submitted (or submitted test results indicate a failed test) by the cut-off prior to the billing date (approximately ten days before the scheduled billing date).

6. If the backflow preventer test fails, the owner must repair and/or replace the device within 30 days of the failed test results and a successful test submitted. No additional testing penalities will be imposed.

7. At the same time, the owner's irrigation system will be in a lock-out status. Lock-outs will be conducted by SPU, with the majority being completed in the off-season. This will prevent usage the following season without proper testing.

8. Upon request by the customer, the testing penalty may be refunded with a successful test submission to The Compliance Engine within 60 days of the original due date.

Lock-Out Tags: Lock-outs may be implemented in two ways. One, the customer requests a lock-out on their system to avoid the annual testing requirement. Two, SPU issues a lock-out due to non-compliance. A tamper seal and lock-out tag will be placed on the backflow preventer. When a system is locked out, the system must not be used. The system must be winterized in order to be locked out.

Removal of Backflow Lock-Out Tag: Only SPU can remove the tamper seal and lock-out tag. If either is altered in any manner, or removed by anyone other than SPU, a $250.00 non-refundable penalty will be charged to the owner's utility account.

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August 8, 2024

Re: Request to Remove $150 charge

This letter responds to your recent communication dated July 30, 2024, requesting Shakopee Public Utilities (SPU) remove the $150 charge regarding backflow prevention testing from the above account. In following SPU's Backflow Prevention and Cross-Connection Control Policy, SPU respectfully denies this request. I will respond specifically to the items you noted.

First, your letter stated that "Minnesota law 603.5. that was passed in 2015 was designated and refer to **Fire sprinklers systems but not to garden sprinklers systems."** Please note the current regulations and Minnesota Plumbing Code are not limited to fire sprinkler systems. The 2020 Minnesota Plumbing Code addresses "water-operated equipment or mechanism" and Section 603.5.6 specifically references "lawn sprinklers and irrigation systems."

Second, your letter states "there is no law in Minnesota that requires testing garden backflow devices installed before 2016." We respectfully direct you to Minnesota Administrative Rule 4714.0603, subpart 1, which requires devices for protection against backflow and testing "at the time of installation, report, or relocation and not less than on an annual schedule thereafter...", and the 2020 Minnesota Plumbing Code, Chapter 6. Neither regulation limits the backflow prevention requirements to 2016 or earlier.

Finally, your letter states "there is no way for water to come to the city water through pipes from garden sprinklers since there is no back pressure in the sprinklers system after sprinklers is turned off." SPU acknowledges that the risk for an individual resident's lawn sprinkler system to contaminate the public water system may be low, but it also notes there are over 6,000 devices connected to Shakopee's water system and the protections of the regulations benefit everyone. SPU is mindful of the need to protect the public water supply for the community as a whole.

We understand that this is a new policy and a change in practice. SPU is focused on doing everything in its power to provide the safest drinking water we can to our customers.

Following SPU's appeal policy, if you accept this response, please acknowledge it with an email or other written response. If you are not in agreement, you have the right to request an audience with the Commission, by contacting me and requesting to be added to an upcoming agenda on this issue for public discussion.

Sincerely,

Gregory L Drent

Greg Drent
General Manager

4714.0603 CROSS-CONNECTION CONTROL.

Subpart 1. **Section 603.2.** UPC section 603.2 is amended to read as follows:

603.2 Approval of Devices or Assemblies. Before a device or an assembly is installed for the prevention of backflow, it shall have first been approved. Devices or assemblies shall be tested in accordance with recognized standards or other approved standards. Backflow prevention devices and assemblies shall comply with Table 603.2, except for specific applications and provisions as stated in sections 603.5.1 through 603.5.23.

Devices or assemblies installed in a potable water supply system for protection against backflow shall be maintained in good working condition by the person or persons having control of such devices or assemblies. The devices or assemblies shall be tested at the time of installation, repair, or relocation and not less than on an annual schedule thereafter, or more often where required by the Authority Having Jurisdiction. Where found to be defective or inoperative, the device or assembly shall be repaired or replaced. No device or assembly shall be removed from use or relocated, or other device or assembly substituted, without the approval of the Authority Having Jurisdiction.

Testing shall be performed by a certified backflow assembly tester in accordance with ASSE Series 5000.

UPC Table 603.2 is not amended.

Subp. 2. **Section 603.5.4.** UPC section 603.5.4 is amended to read as follows:

603.5.4 Heat Exchangers. Heat exchangers used for heat transfer, heat recovery, or solar heating shall protect the potable water system from being contaminated by the heat-transfer medium.

603.5.4.1 Single-Wall Heat Exchanger. Installation of a single-wall heat exchanger shall meet all of the following requirements:

(1) Connected to:

(a) a low-pressure hot water boiler limited to a maximum of 30 pounds-force per square inch gauge (psig) (207 kPa) by an approved safety or relief valve; or

(b) a steam system limited to a maximum of 15 psig (103 kPa).

(2) The heat-transfer medium is either potable water or contains fluids having a toxicity rating or Class of 1.

(3) Bear a label with the word "Caution," followed by the following statements:

(a) The heat-transfer medium shall be water or other nontoxic fluid having a toxicity rating or Class of 1 as listed in Clinical Toxicology of Commercial Products, 5th edition.

(b) The pressure of the heat-transfer medium shall be limited to a maximum of 30 psig (207 kPa) by an approved safety or relief valve.

The word "Caution" and the statements in letters shall have an uppercase height of not less than 0.120 inch (3.048 mm). The vertical spacing between lines of type shall be not less than 0.046 inch (1.168 mm). Lowercase letters shall be compatible with the uppercase letter size specifications.

603.5.4.2 Double-Wall Heat Exchanger. Double-wall heat exchangers shall separate the potable water from the heat-transfer medium by providing a space between the two walls that are vented to the atmosphere.

Subp. 3. **Section 603.5.12.** UPC section 603.5.12 is amended to read as follows:

603.5.12 Beverage Dispensers. Potable water supply to beverage dispensers, carbonated beverage dispensers, or coffee machines shall be protected by an air gap or a vented backflow preventer in accordance with ASSE 1022. For carbonated beverage dispensers, piping materials installed downstream of the backflow preventer shall not be made of copper and not be affected by carbon dioxide gas.

Subp. 4. **Section 603.5.17.** UPC section 603.5.17 is amended to read as follows:

603.5.17 Potable Water Outlets and Valves. Potable water outlets, freeze-proof yard hydrants, combination stop-and-waste valves, or other fixtures that incorporate a stop-and-waste feature that drains into the ground shall not be installed underground except for a freeze-proof yard hydrant that is located at least two feet above the water table and at least ten feet from any sewer or similar source of contamination.

Subp. 5. **Section 603.5.** UPC section 603.5 is amended by adding the following subsections:

603.5.22 Barometric Loop. A barometric loop is an acceptable method of protection of water connections where an actual or potential backsiphonage hazard exists that is not subject to backpressure.

603.5.23 Installation of Testable Backflow Prevention Assembly. Testable backflow prevention assemblies meeting ASSE Standard 1013, 1015, 1020, 1047, 1048, or 1056 shall be installed, tested, maintained, and removed in accordance with sections 603.5.23.1 through 603.5.23.4.

603.5.23.1 Notification of Installation. The administrative authority shall be notified before installation of a testable backflow prevention assembly. The public water supplier shall be notified of the installed testable backflow preventer assembly within 30 days following installation on a community public water system.

603.5.23.2 Testing and Maintenance. The installation of a testable backflow prevention assembly is permitted only when a periodic testing and inspection program conducted by qualified personnel is provided by an agency acceptable to the administrative authority. Inspection intervals shall not exceed one year. The administrative authority may require more frequent testing if deemed necessary to ensure protection of the potable water. A testable backflow prevention assembly shall be inspected after initial installation to ensure that it has been properly installed and that debris resulting from the piping installation has not interfered with the functioning of the assembly.

603.5.23.3 Inspection and Records. A test and inspection tag shall be affixed to the testable backflow prevention assembly. The tester shall date and sign the tag and include the tester's backflow prevention tester certification number. Written records of testing and maintenance shall be maintained and submitted to the administrative authority, and to the public water supplier, within 30 days of testing if installed on a community public water system.

603.5.23.4 Notification of Removal. The Authority Having Jurisdiction, in addition to the public water supplier, shall be notified within 30 days following removal of a testable backflow prevention assembly from a community public water system.

Statutory Authority: *MS s 326B.43; 326B.435*

History: *40 SR 71; 45 SR 1007*
Published Electronically: *September 27, 2021*

4720.0025 UNSAFE WATER CONNECTIONS.

There shall be no physical connection between any public water supply system intended for potable or domestic use and any system, equipment, or device that may serve as a source of contamination, unless protected by a properly maintained backflow preventer approved by the commissioner. Backflow prevention for fire sprinkler systems must comply with American Water Works Association Standard M14, section 6.3, as referenced in part 4715.2110.

Statutory Authority: *MS s 144.383*

History: *18 SR 1960*

Published Electronically: *October 27, 2003*

Distribution System Water Quality

Protecting Water Quality through Cross-Connection Control and Backflow Prevention

Cross-connections are actual or potential connections between a potable water supply and nonpotable water plumbing. Backflow is the unintended reversal of water flow through a cross-connection, which can result in a potentially serious public health hazard. A cross-connection control and backflow prevention program helps prevent contaminants from entering a drinking water distribution system. This fact sheet is part of EPA's Distribution System Toolbox developed to summarize best management practices that public water systems (PWSs), particularly small systems, can use to maintain distribution system water quality and protect public health.

Examples of Utility Actions

At a western United States (U.S.) PWS serving 2,500 people, a customer created a cross-connection when they connected a surface water irrigation line to the water system without installing an approved backflow prevention assembly. Irrigation water flowed back into the county water system when the pressure in the irrigation line increased. Samples tested positive for *E. coli* and the Department of Water issued a "Do Not Use" notice to customers.

A PWS in the southeastern U.S. serving 500,000 people experienced a cross-connection and backflow incident where aqueous fire-fighting foam was forced into the homes of an estimated 40,000 customers. After review of the incident, the PWS installed a backflow prevention assembly.

Cross-Connection Control, Backflow Prevention, and Water Quality

- Backflow of untreated water through an unprotected cross-connection can lead to serious chemical or microbiological contamination in distribution systems.
- Cross-connections can occur between the PWS distribution system and private irrigation systems, fire sprinkler systems, and other piping systems that receive PWS drinking water.
- When the pressure in a PWS distribution system is lower than in the connected plumbing system, backflow contamination can occur.
- A study published by the Water Research Foundation in 2010, using backflow-detecting water meters, found that 5% of homes registered a backflow incident of 1 gallon or more each year. However, the impact of these residential backflow incidents on distribution system disinfectant residual remains undetermined.
- Cross-connection and backflow prevention programs vary by state and municipality. Additional information may be available from state drinking water programs, building code or plumbing authorities, and health departments.
- Sanitary surveys, conducted at least once every three years for community water systems and once every five years for non-community PWSs, offer opportunities to identify potential cross-connections that put public health at risk.

Indicators of a Cross-Connection and Backflow Incident

- Customer complaints of odor, discoloration of water, or direct physical harm are the primary indicators of a backflow incident.
- Decreases in water pressure can indicate the occurrence of a backflow incident, as well as suggest where the incident may have occurred.
- A short-term reduction in disinfectant residual could indicate a potential backflow incident.
- During periods of reversed flow, water meters might run in reverse.

Example of a double check backflow prevention assembly

Cross-Connection Control and Backflow Incident Response

- In the case of a backflow incident, reverse the pressure differential that caused the backflow, if possible.
- Identify and eliminate the cross-connection or install a backflow prevention assembly or device that meets local and state requirements.
- Perform a systematic flushing or cleaning of the system while strategically minimizing the risk of drawing contaminants into uncontaminated areas.
- Throughout the incident, continue to sample within and outside of the suspected contamination area to assess the extent of the contamination.
- Maintain compliance with local discharge regulations for disposal of potentially contaminated water.
- After flushing and cleaning, test the drinking water in the affected areas to ensure it meets regulatory standards.

Example Elements of an Effective Cross-Connection Control and Backflow Prevention Program

- **Legal authority:** PWSs may need legal authority to implement and enforce the program, like requiring customers to install and maintain backflow prevention assemblies. Rules may vary from state to state in terms of allowable backflow prevention assemblies for different hazard types, testing frequency, and remedial repair options.
- **Trained personnel:** All backflow prevention staff should be trained and certified in testing backflow prevention assemblies and distribution system operations. Certification requirements may vary from state to state.
- **Recordkeeping:** Recordkeeping should cover testing and repair activities, certification of inspection and repair personnel, and records associated with backflow prevention assemblies in service, including inspection dates and results.
- **Public education:** PWS customers should understand the potential health risks posed by cross-connections and backflow and their responsibilities for testing and repairing backflow prevention assemblies on irrigation systems or other potential cross-connections.

Table 1: Resources and Guidelines for Cross-Connection Control and Backflow Prevention

Resource Title and URL	Relevance to Cross-Connection Control and Backflow Prevention
ASDWA. 2020. Distribution System Survey White Paper. http://www.asdwa.org/	Summarizes survey findings about state cross-connection control programs.
AWWA. 2015. M14 Backflow Prevention and Cross-Connection Control: Recommended Practices. https://www.awwa.org/	Provides an in-depth analysis of causes and prevention of backflow and cross-connections in potable water systems.
University of Southern California Foundation for Cross-Connection Control and Hydraulic Research. 2012. Manual of Cross-Connection Control, Tenth Edition. https://fccchr.usc.edu/ List of Approved Backflow Prevention Assemblies. https://fccchr.usc.edu/list.html	The manual covers all aspects of cross-connection control and backflow prevention. Associated resources available on the FCCCHR website include a list of tested and approved backflow prevention assemblies and field test kits, training videos, and sample forms to be used in a cross-connection control program.
USEPA. 2006. Cross-Connection Control: A Best Practices Guide. http://nepis.epa.gov/	A concise summary of best practices for cross-connection control.
USEPA. 2003. Cross-Connection Control Manual. http://nepis.epa.gov/	Defines, describes, and illustrates typical cross-connections and suggests simple methods and devices by which cross-connections can be eliminated without interfering with the functioning of plumbing or water supply distribution systems.

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EPA
United States
Environmental Protection
Agency

Office of Water (4601M)
Office of Ground Water and Drinking Water
Distribution System Issue Paper

Potential Contamination Due to Cross-Connections and Backflow and the Associated Health Risks

September 27, 2001

PREPARED BY:

U.S. Environmental Protection Agency
Office of Ground Water and Drinking Water
Standards and Risk Management Division
1200 Pennsylvania Ave., NW
Washington DC 20004

Background and Disclaimer

The USEPA is revising the Total Coliform Rule (TCR) and is considering new possible distribution system requirements as part of these revisions. As part of this process, the USEPA is publishing a series of issue papers to present available information on topics relevant to possible TCR revisions. This paper was developed as part of that effort.

The objectives of the issue papers are to review the available data, information and research regarding the potential public health risks associated with the distribution system issues, and where relevant identify areas in which additional research may be warranted. The issue papers will serve as background material for EPA, expert and stakeholder discussions. The papers only present available information and do not represent Agency policy. Some of the papers were prepared by parties outside of EPA; EPA does not endorse those papers, but is providing them for information and review.

Additional Information

The paper is available at the TCR web site at:

http://www.epa.gov/safewater/disinfection/tcr/regulation_revisions.html

Questions or comments regarding this paper may be directed to **TCR@epa.gov.**

United States Environmental Protection Agency

Cross-Connection Control: A Best Practices Guide

Introduction

Purpose	This Guide discusses the importance of controlling cross-connections and preventing backflow occurrences from unprotected cross-connections in the water system.
Target Audience	This Guide is intended for owners and operators of all public water systems serving fewer than 10,000 persons.

Key Cross-Connection Terms and Definitions

Term	***Definition***
Cross-connection	Any actual or potential connection between the public water supply and a source of contamination or pollution.
Backflow	The flow of water or other liquids, mixtures, or substances into the distributing pipes of a potable supply of water from any source or sources other than its intended source. Backsiphonage is one type of backflow.
Backpressure	Backflow that occurs when the pressure in an unprotected downstream piping system exceeds the pressure in the supply piping.
Backsiphonage	Resulting from negative pressures in the distributing pipes of a potable water supply.

Where Can Cross-Connections Occur?

Cross-connections can occur at many points throughout a distribution system and a community's plumbing infrastructure. Cross-connections can be identified by looking for physical interconnections (or arrangements) between a customer's plumbing and the water system. Some specific examples of backflow incidents that can occur are:

- Lawn chemicals backflowing (backsiphoning) through a garden hose into indoor plumbing and potentially into the distribution system.
- Backsiphonage of "blue water" from a toilet into a building's water supply.
- Carbonated water from a restaurant's soda dispenser entering a water system due to backpressure.
- Backsiphonage of chemicals from industrial buildings into distribution system mains.
- Backflow of boiler corrosion control chemicals into an office building's water supply.

Cross-Connection Control and Backflow Prevention Programs

Why is it Important to Have a Cross-Connection Control and Backflow Prevention Program?

Having a program in place to control cross-connections and prevent backflow is critical to ensuring the safety of the drinking water you provide to your customers:

- Cross-connections are ever-present dangers that exist in most water systems and can result in serious chemical or microbiological contamination events in drinking water systems.
- Cross-connections should be protected in order to prevent backflow, which can be hard to detect.
- In any distribution system, potential cross-connections and therefore sources of contamination can be numerous, varied, and unpredictable.
- Having these programs in place can help you avoid the costs of responding to a contamination incident.

What Do Cross-Connection Control and Backflow Prevention Programs Involve?

Cross-Connection Control and Backflow Prevention Programs vary by state and municipality. For more information, talk with your state primacy drinking water program, state building code or plumbing authority, or health department. Cross-Connection Control Programs may involve:

- Authority to implement and enforce a Cross-Connection Control Program.
- Compliance with state or primacy agency plumbing and building codes or plumbing authority and local ordinances.
- Public education programs.
- Training for water system operators and other personnel on hazard surveys; cross-connection identification; and backflow device installation, testing, repair, and maintenance.
- Record keeping and reporting.
- Installation and testing of devices that prevent backflow consistent with the level of hazard.
- Periodic inspection and testing of devices by certified testers.

How Can I Start Implementing a Cross-Connection Control and Backflow Prevention Program?

You are responsible for ensuring that the water you provide to customers meets all federal and state standards and that its quality is not compromised within your distribution system. Developing a comprehensive Cross-Connection Control and Backflow Prevention Program is one way to ensure the quality of your water and prevent any problems that could occur in your distribution system. If you do not already have a program in place, consider taking the following steps:

- Contact your state primacy or other agency for more information on the basic concepts of cross-connection control and backflow prevention and information on other water systems in your area that have developed a program.
- Determine if you will have to take any legal steps to establish local cross-connection control and backflow prevention ordinances, with assistance from your state and local government.
- List the goals for your program in order of priority. For example, is it more important to develop a public education campaign or to conduct a survey of backflow devices at industrial and commercial facilities served by your system?
- Develop a proposed timeline for implementing your program.
- Review the plan with your local government, state, and any other key stakeholders.
- Hold public meetings and send notices to customers to educate the community about the need for a program and how it may affect them.
- Plan to monitor your progress in implementing your program and protecting public health.
- Conduct initial hazard testing, as required.

How Can I Reduce and Prevent Cross-Connections?	
Plumbing and Distribution System Operation Practices	◆ Hire approved personnel for the installation of any contaminant backflow prevention devices to ensure that local codes and manufacturer's recommendations are met. ◆ Use only assemblies or devices approved by the appropriate state or local authority. ◆ Test all backflow prevention devices at the frequencies recommended or required by your state. ◆ Provide backflow prevention in new construction through coordination with the local building inspector's office.
Inspections	◆ For existing buildings, develop a program in-house or with plumbing or water system personnel to inspect for the adequacy of cross-connection control. Prioritize inspections based upon the expected degree of risk. ◆ Make sure that a backflow inspector conducts inspections for hazards to be controlled. ◆ For both new construction and existing buildings, require continued inspection and testing of backflow devices.
Fire Hydrant Connection Procedures	◆ Ensure that construction contractors or anyone using a hydrant to fill a tank intended to carry potable water exercises safe fire hydrant connection procedures to prevent backflow.

What Technologies are Available to Control Cross-Connections and Prevent Backflow?

The type of backflow that is most likely to occur in your system (either from backpressure or backsiphonage) and the related health effects will determine which backflow prevention technology is best for your water system. The available technologies are described briefly below.

Technology	***Description***
Atmospheric Vacuum Breaker	◆ Consists of float check, check seat, air inlet port, and possibly a shutoff valve immediately upstream. ◆ Allows air to enter the downstream water connection to prevent backsiphonage. ◆ Used for backsiphonage conditions only.
Pressure Vacuum Breaker Devices	◆ Consist of vacuum breakers with a loaded check valve and a loaded air inlet valve. ◆ Used for backsiphonage conditions only.
Double Check Valve Devices	◆ Consist of two independently acting, tightly closing, resilient seated check valves in series with test ports. ◆ Have tightly closing, resilient seated shutoff valves attached at each end of the assembly. ◆ Prevent backflow under backsiphonage and backpressure conditions. ◆ Typically approved for only low to medium hazards.
Air Gaps	◆ Physical separation between a potable water system and a receiving vessel or source of contamination. ◆ Air gap between the outlet of the potable system and the flood level rim of the receiving vessel or any source of contamination must be at least twice as large as the diameter of the potable water outlet and never smaller than 1 inch. ◆ May require additional pumping downstream of air gap. ◆ Safest and simplest means under backsiphonage and backpressure conditions. ◆ Useful for all hazard levels.
Reduced Pressure Zone Backflow Devices	◆ Similar to the double check valve devices, but also contain an independently acting pressure relief valve between the two check valves (which sits lower than the first check valve). ◆ Protect against high water pollution hazards. ◆ Protect against backsiphonage and backpressure.

What Should I Do in Case of a Backflow Event?

Step 1	◆ Stop the pressure differential that caused backflow of contamination, if possible. ◆ Identify and remove the cross-connection.
Step 2	◆ Contact appropriate state or local authorities to report the incident. ◆ In areas where public exposure to harmful contaminants is suspected, provide immediate notice to affected consumers regarding water usage and consumption and contact appropriate state or local authorities to report the incident. Public notice should explain the cause of the contamination and corrective actions that are underway and should include any appropriate health effects language. ◆ Provide updated public notification as appropriate during and after removal of contamination from the system.
Step 3	◆ If the contamination is limited to a small area, proceed to step 6. ◆ If the extent of the contamination is unknown or is extensive, proceed to step 4. (If sampling and testing of the water can be arranged immediately, the results could be used to determine the extent of the contaminants involved.)
Step 4	◆ Develop a plan for systematic cleaning or flushing of the system to minimize the risk of drawing contaminants into uncontaminated areas. ◆ The plan should indicate the amount of water and the length of time needed to completely flush the system. The direction of flow should draw clean water through the contaminated site and prevent any contaminated water from entering uncontaminated areas. Depending upon the nature of the contamination, some wastes may be discharged into the sanitary sewer system and some may need special handling or treatment.
Step 5	◆ Throughout the situation, continue to sample within and outside the suspected contaminated area to assess the extent of the damage. Skip step 6.
Step 6	◆ Perform system flushing and, where necessary, cleaning of the customer's system.
Step 7	◆ After flushing and any necessary cleaning, test the drinking water in affected areas to ensure the contamination has been removed.
Step 8	◆ Ensure that the source of contamination has been removed or that the risk of contamination has been eliminated using backflow prevention measures that meet local and state requirements.

For additional information:
Call the Safe Drinking Water Hotline at 1-800-426-4791, visit the EPA Web site at www.epa.gov/safewater/smallsys.html, or contact your State drinking water representative.

Office of Water September 2006 EPA 816-F-06-035

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Cross-Connection Control Manual

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Preface

Plumbing cross-connections, which are defined as actual or potential connections between a potable and non-potable water supply, constitute a serious public health hazard. There are numerous, well-documented cases where cross-connections have been responsible for contamination of drinking water, and have resulted in the spread of disease. The problem is a dynamic one, because piping systems are continually being installed, altered, or extended.

Control of cross-connections is possible, but only through thorough knowledge and vigilance. Education is essential, for even those who are experienced in piping installations fail to recognize cross-connection possibilities and dangers. All municipalities with public water supply systems should have cross-connection control programs. Those responsible for institutional or private water supplies should also be familiar with the dangers of cross-connections and should exercise careful surveillance of their systems.

This *Cross-Connection Control Manual* has been designed as a tool for health officials, waterworks personnel, plumbers, and any others involved directly or indirectly in water supply distribution systems. It is intended to be used for educational, administrative, and technical reference in conducting cross-connection control programs. This manual is a revision of an earlier book entitled *Water Supply and Plumbing Cross-Connections* (PHS Publication Number 957), which was produced under the direction of Floyd B. Taylor by Marvin T. Skodje, who wrote the text and designed the illustrations.

Many of the original illustrations and text have been retained in this edition. Previous revisions were done by Peter C. Karalekas, Jr. with guidance from Roger D. Lee incorporating suggestions made by the staff of the EPA Water Supply Division, other governmental agencies, and interested individuals.

This 3rd edition was produced as a result of an updated need for cross-connection control reference material reflecting an increase in cross-connection control activity throughout the United States. It has been revised and re-issued reflecting a demand for its use, together with requests for a document that covers the broad spectrum of cross-connection control from both the basic hydraulic concepts through the inclusion of a sample program that can be a guide for a program at the municipal level. New backflow devices have been included in this revision that are now being produced by manufacturers reflecting the needs of the market. Updated actual cross-connection case histories have been added containing graphic schematic illustrations showing how the incidents occurred and how cross-connection control practices could be applied to eliminate future re-occurrence. A more detailed explanation of cross-connection control "containment" practice has been included together with the use for "internal backflow protective devices" and "fixture outlet protection".

This 1989 edition was prepared by Howard D. Hendrickson, PE, vice president of Water Service Consultants, with assistance from Peter C. Karalekas, Jr. of Region 1, EPA, Boston.

This latest (2003) edition has technical corrections provided by Howard D. Hendrickson, P.E., showing updates on pages iv, 18, 23, 30, 31, and 32.

Contents

An AWWA Statement of Policy on Public Water Supply Matters.

Cross Connections

Adopted by the Board of Directors Jan. 26, 1970, revised June 24, 1979, reaffirmed June 10, 1984 and revised Jan. 28, 1990 and Jan. 21, 2001.

The American Water Works Association (AWWA) recognizes water purveyors have the responsibility to supply potable water to their customers. In the exercise of this responsibility, water purveyors or other responsible authorities must implement, administer, and maintain ongoing backflow prevention and cross-connection control programs to protect public water systems from the hazards originating on the premises of their customers and from temporary connections that may impair or alter the water in the public water systems. The return of any water to the public water system after the water has been used for any purpose on the customer's premises or within the customer's piping system is unacceptable and opposed by AWWA.

The water purveyor shall assure that effective backflow prevention measures commensurate with the degree of hazard, are implemented to ensure continual protection of the water in the public water distribution system. Customers, together with other authorities are responsible for preventing contamination of the private plumbing system under their control and the associated protection of the public water system.

If appropriate back-flow prevention measures have not been taken, the water purveyor shall take or cause to be taken necessary measures to ensure that the public water distribution system is protected from any actual or potential backflow hazard. Such action would include the testing, installation, and continual assurance of proper operation and installation of backflow-prevention assemblies, devices, and methods commensurate with the degree of hazard at the service connection or at the point of cross connection or both. If these actions are not taken, water service shall ultimately be eliminated.

To reduce the risk private plumbing systems pose to the public water distribution system, the water purveyor's backflow prevention program should include public education regarding the hazards backflow presents to the safety of drinking water and should include coordination with the cross connection efforts of local authorities, particularly health and plumbing officials. In areas lacking a health or plumbing enforcement agency, the water purveyor should additionally promote the health and safety of private plumbing systems to protect its customers from the hazards of backflow.

Purpose and Scope

Public health officials have long been concerned about cross-connections and backflow connections in plumbing systems and in public drinking water supply distribution systems. Such cross-connections, which make possible the contamination of potable water, are ever-present dangers. One example of what can happen is an epidemic that occurred in Chicago in 1933. Old, defective, and improperly designed plumbing and fixtures permitted the contamination of drinking water. As a result. 1,409 persons contracted amebic dysentery; there were 98 deaths. This epidemic, and others resulting from contamination introduced into a water supply through improper plumbing, made clear the responsibility of public health officials and water purveyors for exercising control over public water distribution systems and all plumbing systems connected to them. This responsibility includes advising and instructing plumbing installers in the recognition and elimination of cross-connections.

Cross-connections are the links through which it is possible for contaminating materials to enter a potable water supply. The contaminant enters the potable water system when the pressure of the polluted source exceeds the pressure of the potable source. The action may be called backsiphonage or backflow. Essentially it is reversal of the hydraulic gradient that can be produced by a variety of circumstances.

It might be assumed that steps for detecting and eliminating cross-connections would be elementary and obvious. Actually, cross-connections may appear in many subtle forms and in unsuspected places. Reversal of pressure in the water may be freakish and unpredictable. The probability of contamination of drinking water through a cross-connection occurring within a single plumbing system may seem remote; but, considering the multitude of similar systems, the probability is great.

Why do such cross-connections exist?

First, plumbing is frequently installed by persons who are unaware of the inherent dangers of cross-connections. Second, such connections are made as a simple matter of convenience without regard to the dangerous situation that might be created. And, third, they are made with reliance on inadequate protection such as a single valve or other mechanical device.

To combat the dangers of cross-connections and backflow connections, education in their recognition and prevention is needed. First, plumbing installers must know that hydraulic and pollutional factors may combine to produce a sanitary hazard if a cross-connection is present. Second, they must realize that there are available reliable and simple standard backflow prevention devices and methods that may be substituted for the convenient but dangerous direct connection. And third, it should be made clear to all that the hazards resulting from direct connections greatly outweigh the convenience gained. This manual does not describe all the cross-connections possible in piping systems. It does attempt to reduce the subject to a statement of the principles involved and to make it clear to the reader that such installations are potentially dangerous. The primary purpose is to define, describe, and illustrate typical cross-connections and to suggest simple methods and devices by which they may be eliminated without interfering with the functions of plumbing or water supply distribution systems.

Public Health Significance of Cross-Connections

Public health officials have long been aware of the impact that cross-connections play as a threat to the public health. Because plumbing defects are so frequent and the opportunity for contaminants to invade the public drinking water through cross-connections are so general, enteric illnesses caused by drinking water may occur at most any location and at any time.

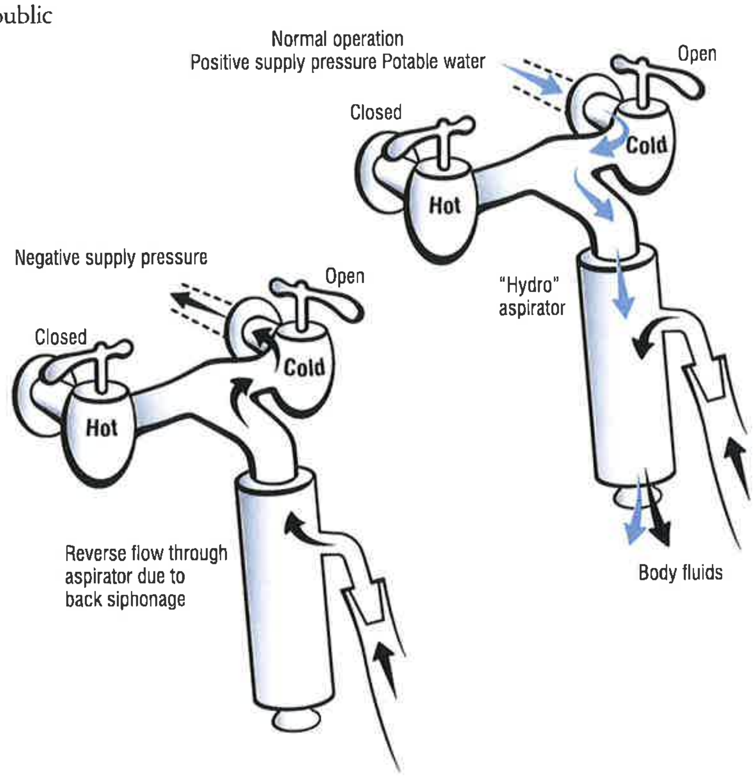
The following documented cases of cross-connection problems illustrate and emphasize how actual cross-connections have compromised the water quality and the public health.

Human Blood in the Water System

Health Department officials cut off the water supply to a funeral home located in a large southern city, after it was determined that human blood had contaminated the fresh water supply. City water and plumbing officials said that they did not think that the blood contamination had spread beyond the building, however, inspectors were sent into the neighborhood to check for possible contamination. The chief plumbing inspector had received a telephone call advising that blood was coming from drinking fountains within the building. Plumbing and county health department inspectors went to the scene and found evidence that the blood had been circulating in the water system within the building. They immediately ordered the building cut off from the water system at the meter.

Investigation revealed that the funeral home had been using a hydraulic aspirator to drain fluids from the bodies of human "remains" as part of the embalming process. The aspirator directly connected to the water supply system at a faucet outlet located on a sink in the "preparation" (embalming) room. Water flow through the aspirator created suction that was utilized to draw body fluids through a hose and needle attached to the suction side of the aspirator.

The contamination of the funeral home potable water supply was caused by a combination of low water pressure in conjunction with the simultaneous use of the aspirator. Instead of the body fluids flowing into the sanitary drain, they were drawn in the opposite direction—into the potable water supply of the funeral home!



Burned in the Shower

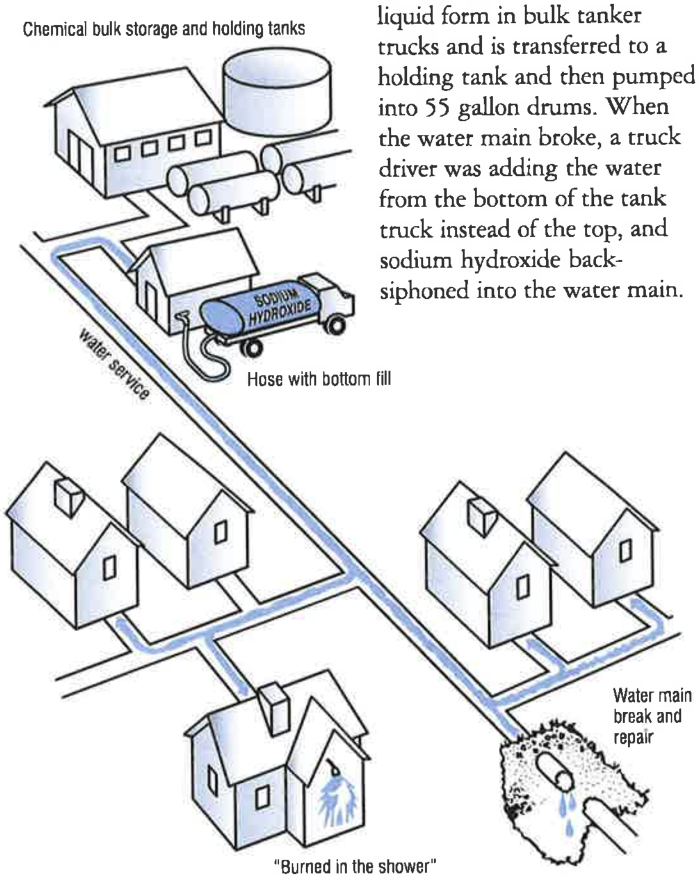
A resident of a small town in Alabama, jumped in the shower at 5 a.m. one morning in October, 1986, and when he got out his body was covered with tiny blisters. "The more I rubbed it, the worse it got," the 60 year old resident said. "It looked like someone took a blow torch and singed me."

He and several other residents received medical treatment at the emergency room of the local hospital after the water system was contaminated with sodium hydroxide, a strong caustic solution.

Other residents claimed that, "It (the water) bubbled up and looked like Alka Seltzer. I stuck my hand under the faucet and some blisters came up." One neighbor's head was covered with blisters after she washed her hair and others complained of burned throats or mouths after drinking the water.

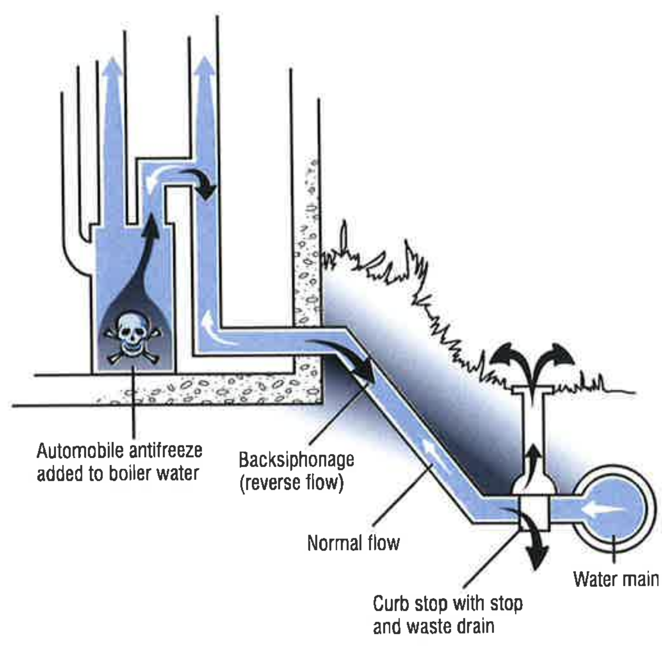
The incident began after an 8-inch water main, that fed the town, broke and was repaired. While repairing the water main, one workman suffered leg burns from a chemical in the water and required medical treatment. Measurements of the ph of the water were as high as 13 in some sections of the pipe.

Investigation into the cause of the problem led to a possible source of the contamination from a nearby chemical company that distributes chemicals such as sodium hydroxide. The sodium hydroxide is brought to the plant in liquid form in bulk tanker trucks and is transferred to a holding tank and then pumped into 55 gallon drums. When the water main broke, a truck driver was adding the water from the bottom of the tank truck instead of the top, and sodium hydroxide backsiphoned into the water main.



Heating System Anti-Freeze into Potable Water

Bangor Maine Water Department employees discovered poisonous antifreeze in a homeowner's heating system and water supply in November, 1981. The incident occurred when they shut off 'the service line to the home to make repairs. With the flow of water to the house cut off, pressure in the lines in the house dropped and the antifreeze, placed in the heating system to prevent freeze-up of an unused hot water heating system, drained out of the heating system into house water lines, and flowed out to the street. If it had not been noticed, it would have entered the homeowner's drinking water when the water pressure was restored.

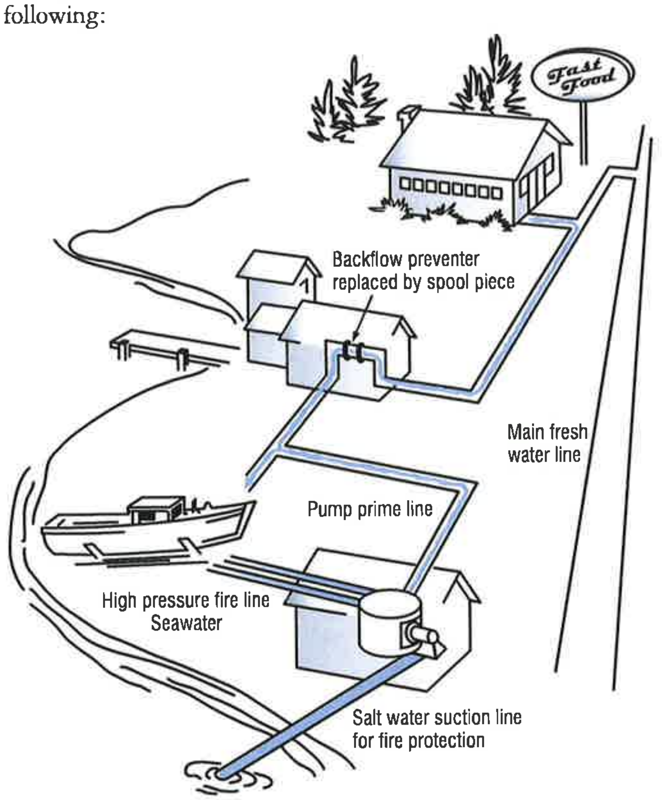


Salty Drinks

In January, 1981, a nationally known fast food restaurant located in southeastern United States, complained to the water department that all their soft drinks were being rejected by their customers as tasting "salty." This included soda fountain beverages, coffee, orange juice, etc. An investigation revealed that an adjacent water customer complained of salty water occurring simultaneously with the restaurant incident. This second complaint came from a water front ship repair facility that was also being served by the same water main lateral. The (investigation centered on the ship repair facility and revealed the following:

- A backflow preventer that had been installed on the service line to the shipyard had frozen and had been replaced with a spool piece sleeve.
- The shipyard fire protection system utilized sea water that was pumped by both electric and diesel driven pumps.
- The pumps were primed by potable city water.

With the potable priming line left open and the pumps maintaining pressure in the fire lines, raw salt water was pumped through the priming lines, through the spool sleeve piece, to the ship repair facility and the restaurant.



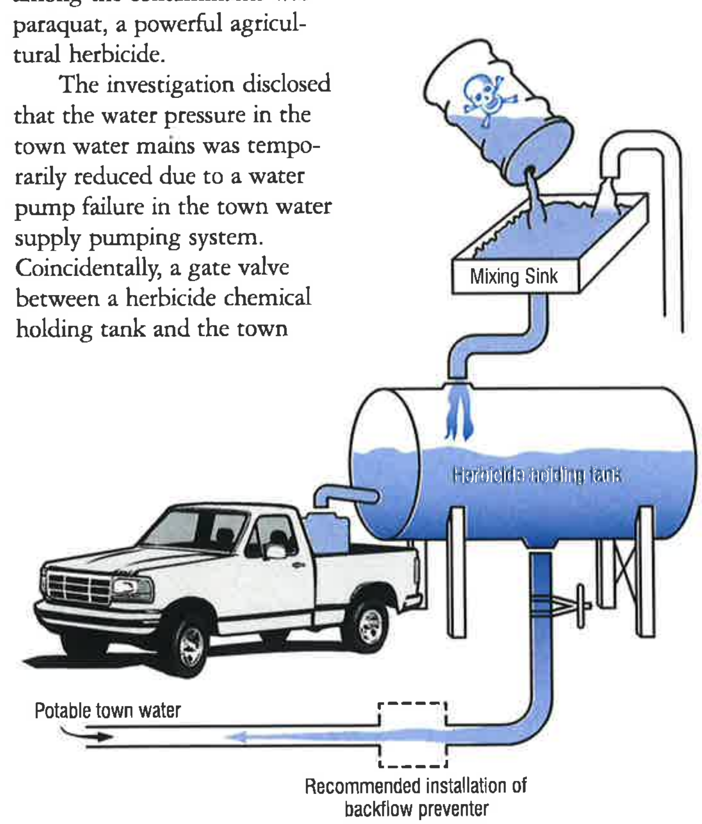
Paraquat in the Water System

"Yellow gushy stuff" poured from some of the faucets in a small town in Maryland, and the State of Maryland placed a ban on drinking the water supply. Residents were warned not to use the water for cooking, bathing, drinking or any other purpose except for flushing toilets.

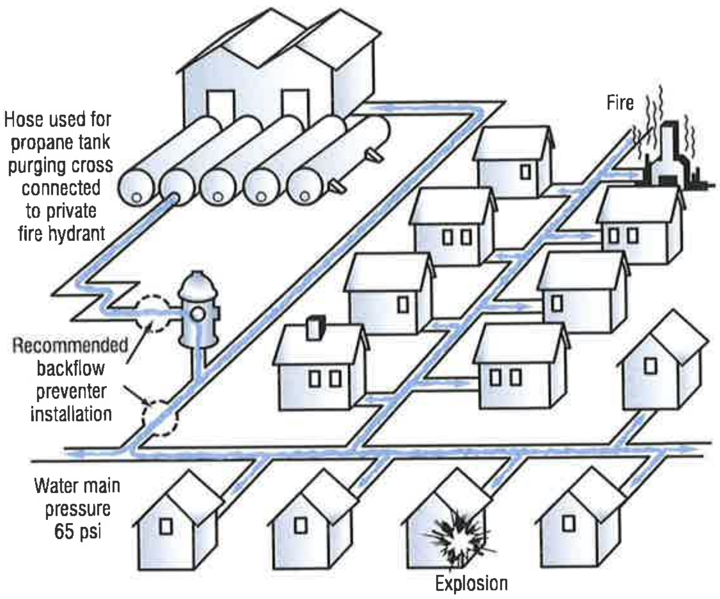
The incident drew widespread attention and made the local newspapers. In addition to being the lead story on the ABC news affiliate in Washington, D.C. and virtually all the Washington/Baltimore newspapers that evening. The news media contended that lethal pesticides may have contaminated the water supply and among the contaminants was paraquat, a powerful agricultural herbicide.

The investigation disclosed that the water pressure in the town water mains was temporarily reduced due to a water pump failure in the town water supply pumping system. Coincidentally, a gate valve between a herbicide chemical holding tank and the town water supply piping had been left open. A lethal cross-connection had been created that permitted the herbicide to flow into the potable water supply system. Upon restoration of water pressure, the herbicides flowed into the many faucets and outlets on the town water distribution system.

This cross-connection created a needless and costly event that fortunately did not result in serious illness or loss of life. Door-to-door public notification, extensive flushing, water sample analysis, emergency arrangements to provide temporary potable water from tanker trucks, all contributed to an expensive and unnecessary town burden.



Propane Gas in the Water Mains



Hundreds of people were evacuated from their homes and businesses on an August afternoon in a town in Connecticut in 1982 as a result of propane entering the city water supply system. Fires were reported in two homes and the town water supply was contaminated. One five-room residence was gutted by a blaze resulting from propane gas "bubbling and hissing" from a bathroom toilet and in another home a washing machine explosion blew a woman against a wall. Residents throughout the area reported hissing, bubbling noises, coming from washing machines, sinks and toilets. Faucets sputtered out small streams of water mixed with gas and residents in the area were asked to evacuate their homes.

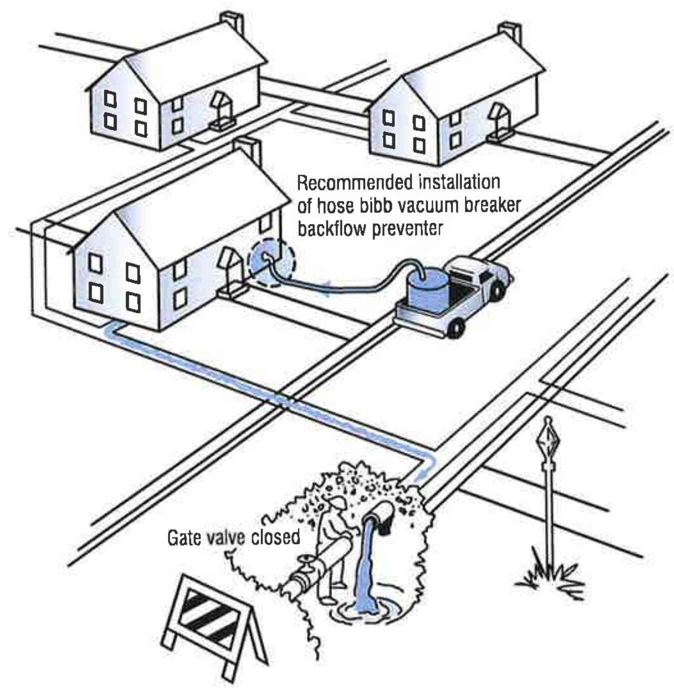
This near-disaster occurred in one, 30,000 gallon capacity liquid propane tank when the gas company initiated immediate repair procedures. To start the repair, the tank was "purged" of residual propane by using water from one of two private fire hydrants located on the property. Water purging is the preferred method of purging over the use of carbon dioxide since it is more positive and will float out any sludge as well as any gas vapors. The "purging" consisted of hooking up a hose to one of the private fire hydrants located on the property and initiating flushing procedures.

Since the vapor pressure of the propane residual in the tank was 85 to 90 psi., and the water pressure was only 65 to 70 psi., propane gas backpressure backflowed into the water main. It was estimated that the gas flowed into the water mains for about 20 minutes and that about 2,000 cubic feet of gas was involved. This was approximately enough gas to fill one mile of an 8-inch water main.

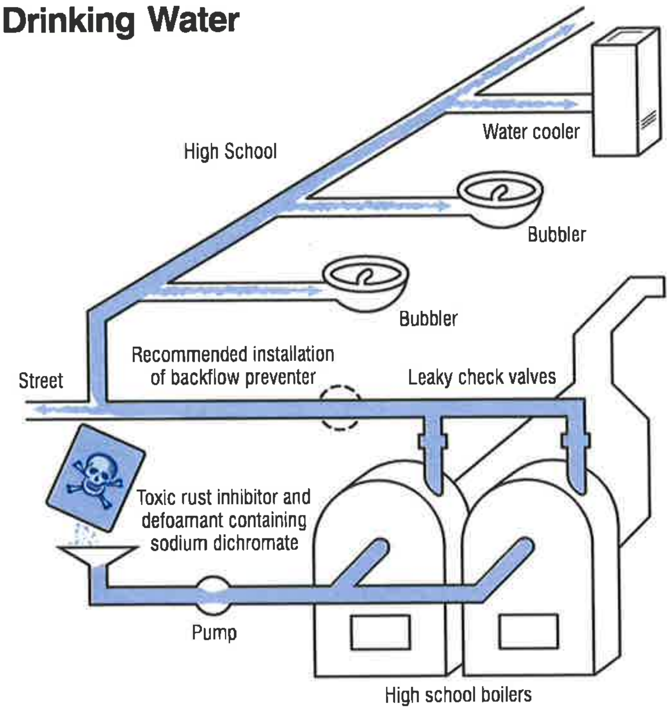
Chlordane and Heptachlor at the Housing Authority

The services to seventy five apartments housing approximately three hundred people were contaminated with chlordane and heptachlor in a city in Pennsylvania, in December, 1980. The insecticides entered the water supply system while an exterminating company was applying them as a preventative measure against termites. While the pesticide contractor was mixing the chemicals in a tank truck with water from a garden hose coming from one of the apartments, a workman was cutting into a 6-inch main line to install a gate valve. The end of the garden hose was submerged in the tank containing the pesticides, and at the same time, the water to the area was shut off and the lines being drained prior to the installation of the gate valve. When the workman cut the 6-inch line, water started to drain out of the cut, thereby setting up a backsiphonage condition. As a result, the chemicals were siphoned out of the truck, through the garden hose, and into the system, contaminating the seventy five apartments.

Repeated efforts to clean and flush the lines were not satisfactory and it was finally decided to replace the water line and all the plumbing that was affected. There were no reports of illness, but residents of the housing authority were told not to use any tap water for any purpose and they were given water that was trucked into the area by volunteer fire department personnel. They were without their normal water supply for 27 days.



Boiler Water Enters High School Drinking Water



A high school in New Mexico, was closed for several days in June 1984 when a home economics teacher noticed the water in the potable system was yellow. City chemists determined that samples taken contained levels of chromium as high as 700 parts per million, "astronomically higher than the accepted levels of .05 parts per million." The head chemist said that it was miraculous that no one was seriously injured or killed by the high levels of chromium. The chemical was identified as sodium dichromate, a toxic form of chromium used in heating system boilers to inhibit corrosion of the metal parts.

No students or faculty were known to have consumed any of the water; however, area physicians and hospitals advised that if anyone had consumed those high levels of chromium, the symptoms would be nausea, diarrhea, and burning of the mouth and throat. Fortunately, the home economics teacher, who first saw the discolored water before school started, immediately covered all water fountains with towels so that no one would drink the water.

Investigation disclosed that chromium used in the heating system boilers to inhibit corrosion of metal parts entered the potable water supply system as a result of backflow through leaking check valves on the boiler feed lines.

Pesticide in Drinking Water

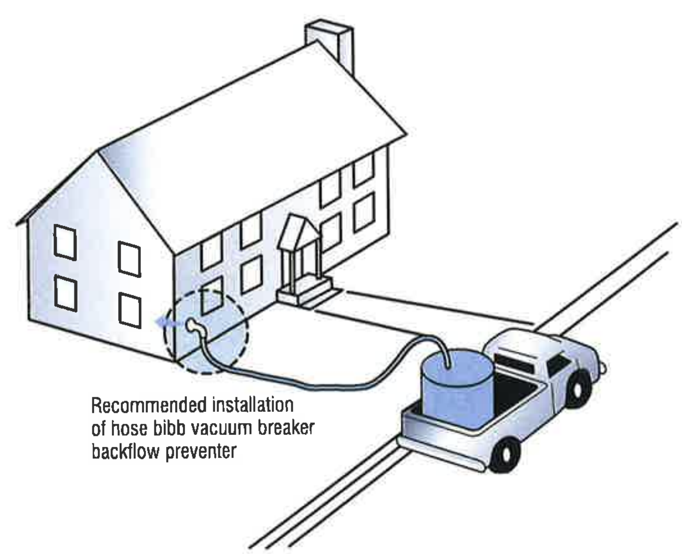
A pesticide contaminated a North Carolina water system in April, 1986, prompting the town to warn residents of 23 households not to drink the water. The residents in the affected area were supplied drinking water from a tank truck parked in the parking lot of a downtown office building until the condition could be cleared up. Residents complained of foul smelling water but there were no reports of illness from ingesting the water that had been contaminated with a pesticide containing chlordane and heptachlor.

Authorities stated that the problem occurred when a water main broke at the same time that a pest control service was filling a pesticide truck with water. The reduction in pressure caused the pesticide from inside the tank to be sucked into the building's water main. The pesticide contaminated the potable water supply of the office building and neighborhood area.

Car Wash Water in the Water Main Street

This car wash cross-connection and back-pressure incident, which occurred in February, 1979, in the state of Washington, resulted in backflow chemical contamination of approximately 100 square blocks of water mains. Prompt response by the water department prevented a potentially hazardous water quality degradation problem without a recorded case of illness.

Numerous complaints of grey-green and "slippery" water were received by the water department coming from the same general area of town. A sample brought to the water department by a customer confirmed the reported problem and preliminary analysis indicated contamination with what appeared to be a detergent solution. While emergency crews initiated flushing operations, further investigation within the contaminated area signaled the problem was probably caused by a car wash,



or laundry, based upon the soapy nature of the contaminant. The source was quickly narrowed down to a car wash and the proprietor was extremely cooperative in admitting to the problem and explaining how it had occurred. The circumstances leading up to the incident were as follows:

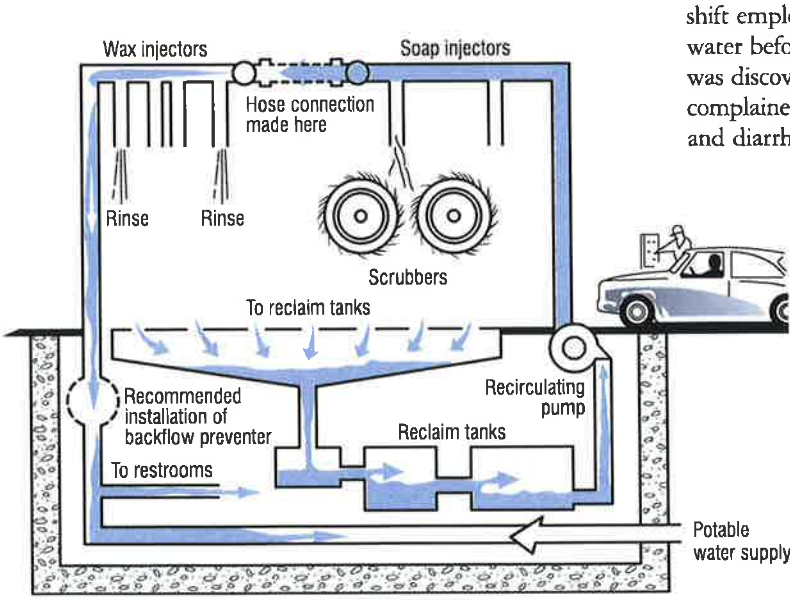
• On Saturday, February 10, 1979, a high pressure pump broke down at the car wash. This pump recycled reclaimed wash and rinse water and pumped it to the initial scrubbers of the car wash. No potable plumbing connection is normally made to the car wash's scrubber system.

• After the pump broke down, the car wash owner was able to continue operation by connecting a 2-inch hose section temporarily between the potable supply within the car wash, and the scrubber cycle piping.

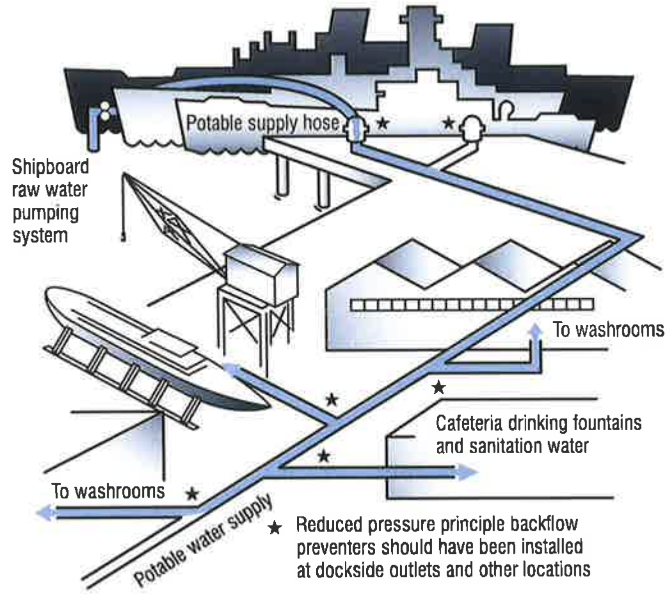
• On Monday, February 12, 1979, the owner repaired the high pressure pump and resumed normal car wash operations. The 2-inch hose connection (cross-connection) was not removed!

• Because of the cross-connection, the newly repaired high pressure pump promptly pumped a large quantity of the reclaimed wash/rinse water out of the car wash and into a 12-inch water main in the street. This in turn was delivered to the many residences and commercial establishments connected to the water main.

Within 24 hours of the incident, the owner of the car wash had installed a 2-inch reduced pressure principle backflow preventer on his water service and all car wash establishments in Seattle that used a wash water reclaim system were notified of the state requirement for backflow prevention.



Shipyard Backflow Contamination



Water fountains at an East Coast Shipyard were posted "No Drinking" as workers flushed the water lines to eliminate raw river water that had entered the shipyard following contamination from incorrectly connected water lines between ships at the pier and the shipyard. Some third shift employees drank the water before the pollution was discovered and later complained of stomach cramps and diarrhea.

The cause of the problem was a direct cross-connection between the on-board salt water fire protection water system and the fresh water connected to one of the ships at the dock. While the shipyard had been aware of the need for backflow protection at the dockside tie up area, the device had not been delivered and installed prior to the time of the incident. As a result, the salt water on-board fire protection system, being at a greater pressure than the potable supply, forced the salt water, through backpressure, into the shipyard potable supply.

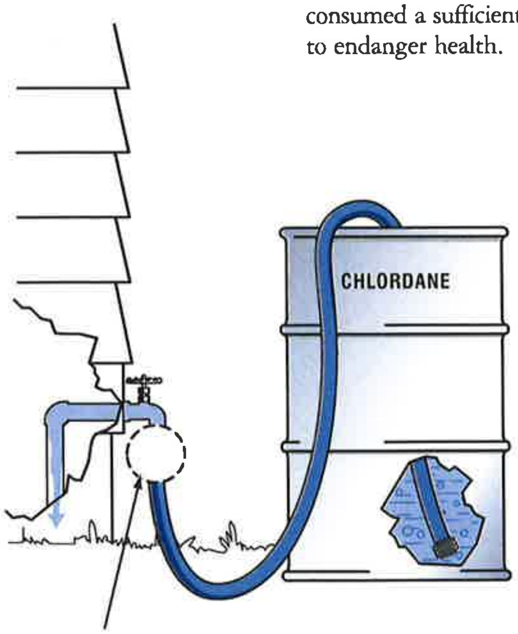
Fortunately, a small demand for potable water at the time of the incident prevented widespread pollution in the shipyard and the surrounding areas.

Chlordane in the Water Main

In October, 1979, approximately three gallons of chlordane, a highly toxic insecticide, was sucked back (back-siphoned) into the water system of a residential area of a good sized eastern city. Residents complained that the water "looked milky, felt greasy, foamed and smelled," and as one woman put it, "It was similar to a combination of kerosene and Black Flag pesticide."

The problem developed while water department personnel were repairing a water main. A professional exterminator, meanwhile, was treating a nearby home with chlordane for termite elimination. The workman for the exterminator company left one end of a garden hose that was connected to an outside hose bibb tap in a barrel of diluted pesticide. During the water service interruption, the chlordane solution was back-siphoned from the barrel through the house and into the water mains.

Following numerous complaints, the water department undertook an extensive program of flushing of the water mains and hand delivered letters telling residents to flush their lines for four hours before using the water. Until the water lines were clear of the contaminant, water was hand-hauled into homes, and people went out of their homes for showers, meals and every other activity involving potable water. Fortunately, due to the obvious bad taste, odor and color of the contaminated water, no one consumed a sufficient quantity to endanger health.



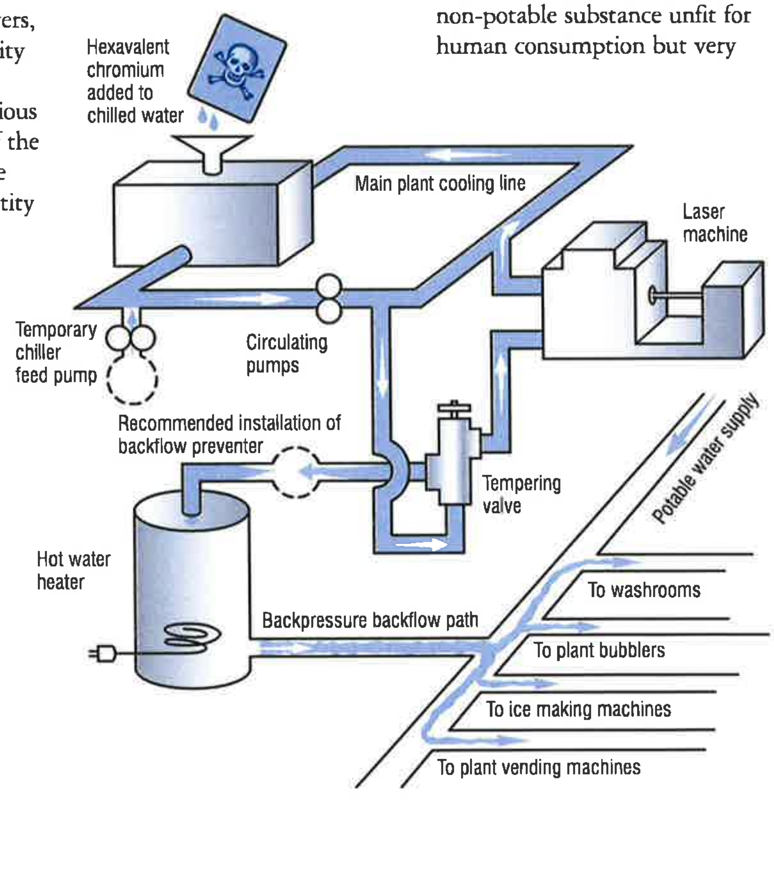
Recommended installation of hose bibb vacuum breaker backflow preventer

Hexavalent Chromium in Drinking Water

In July, 1982, a well meaning maintenance mechanic, in attempting to correct a fogging lens in an overcooled laser machine, installed a tempering valve in the laser cooling line, and inadvertently set the stage for a backpressure backflow incident that resulted in hexavalent chromium contaminating the potable water of a large electronic manufacturing company in Massachusetts employing 9,000 people. Quantities of 50 parts per million hexavalent chromium were found in the drinking water which is sufficient to cause severe vomiting, diarrhea, and intestinal sickness. Maintenance crews working during the plant shutdown were able to eliminate the cross-connection and thoroughly flush the potable water system, thereby preventing a serious health hazard from occurring.

The incident occurred as follows:

• Laser machine lenses were kept cool by circulating chilled water that came from a large refrigeration chiller. The water used in the chiller was treated with hexavalent chromium, a chemical additive used as an anticorrosive agent and an algicide. As a result, the chilled water presented a toxic, non-potable substance unfit for human consumption but very



acceptable for industrial process water. No health hazard was present as long as the piping was identified, kept separate from potable drinking water lines, and not cross-connected to the potable water supply.

• A maintenance mechanic correctly reasoned that by adding a tempering valve to the chilled water line, he could heat up the water a bit and eliminate fogging of the laser lenses resulting from the chilled water being too cold. The problem with the installation of the tempering valve was that a direct cross-connection had been inadvertently made between the toxic chilled water and the potable drinking water line!

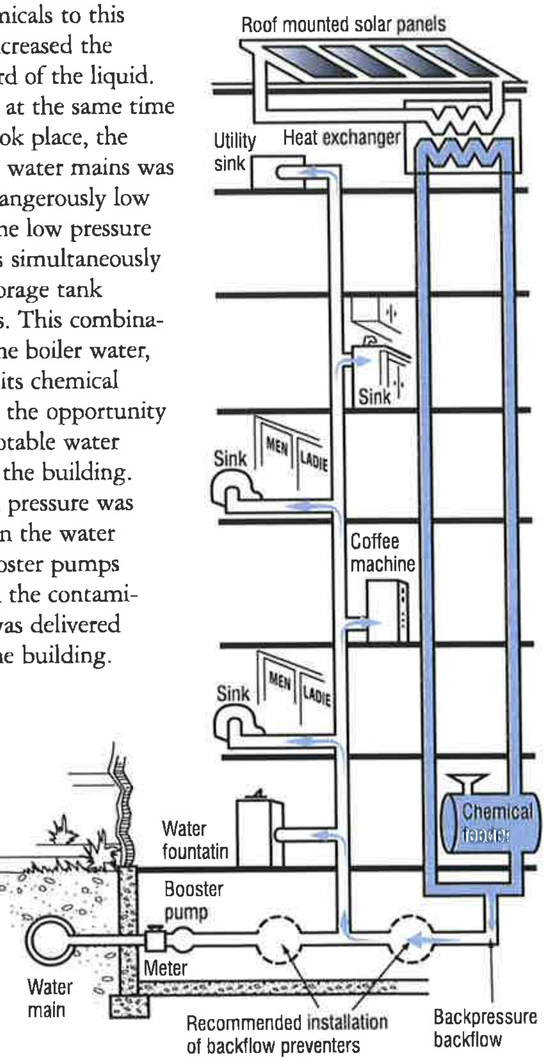
• Periodic maintenance to the chiller system was performed in the summer, requiring that an alternate chiller feed pump be temporarily installed. This replacement pump had an outlet pressure of 150 psi, and promptly established an imbalance of pressure at the tempering valve, thereby overpressurizing the 60 psi, potable supply. Backpressure backflow resulted and pushed the toxic chilled water from the water heater and then into the plant's potable drinking water supply. Yellowish green water started pouring out of the drinking fountains, the washroom, and all potable outlets.

Employee Health Problems due to Cross-Connection

A cross-connection incident occurring in a modern seven-story office building located in a large city in New Hampshire, in March, 1980, resulted in numerous cases of nausea, diarrhea, loss of time and employee complaints as to the poor quality of the water.

On Saturday, March 1, 1980, a large fire occurred two blocks away from a seven-story office building in this large New Hampshire city. On Sunday, March 2, 1980, the maintenance crew of the office building arrived to perform the weekly cleaning, and after drinking the water from the drinking fountains, and sampling the coffee from the coffee machines, noticed that the water smelled rubbery and had a strong bitter taste. Upon notifying the Manchester Water Company, water samples were taken and preliminary analysis disclosed that the contaminants found were not the typical contaminants associated with fire line disturbances. Investigating teams suspected that either the nearby fire could have siphoned contaminants from adjacent buildings into the water mains, or the contamination could have been caused by a plumbing deficiency occurring within the seven story building itself.

Water ph levels of the building water indicated that an injection of chemicals had probably taken place within the seven-story building. Tracing of the water lines within the building pinpointed a 10,000 gallon hot-water storage tank that was used for heat storage in the solar heating system. It did not have any backflow protection on the make-up supply line! As the storage tank pressure increased above the supply pressure, as a result of thermal expansion, the potential for backpressure backflow was present. Normally, this would not occur because a boost pump in the supply line would keep the supply pressure to the storage tank always greater than the highest tank pressure. The addition of rust inhibiting chemicals to this tank greatly increased the degree of hazard of the liquid. Unfortunately, at the same time that the fire took place, the pressure in the water mains was reduced to a dangerously low pressure and the low pressure cutoff switches simultaneously shut off the storage tank booster pumps. This combination allowed the boiler water, together with its chemical contaminants, the opportunity to enter the potable water supply within the building. When normal pressure was reestablished in the water mains, the booster pumps kicked in, and the contaminated water was delivered throughout the building.



Dialysis Machine Contamination

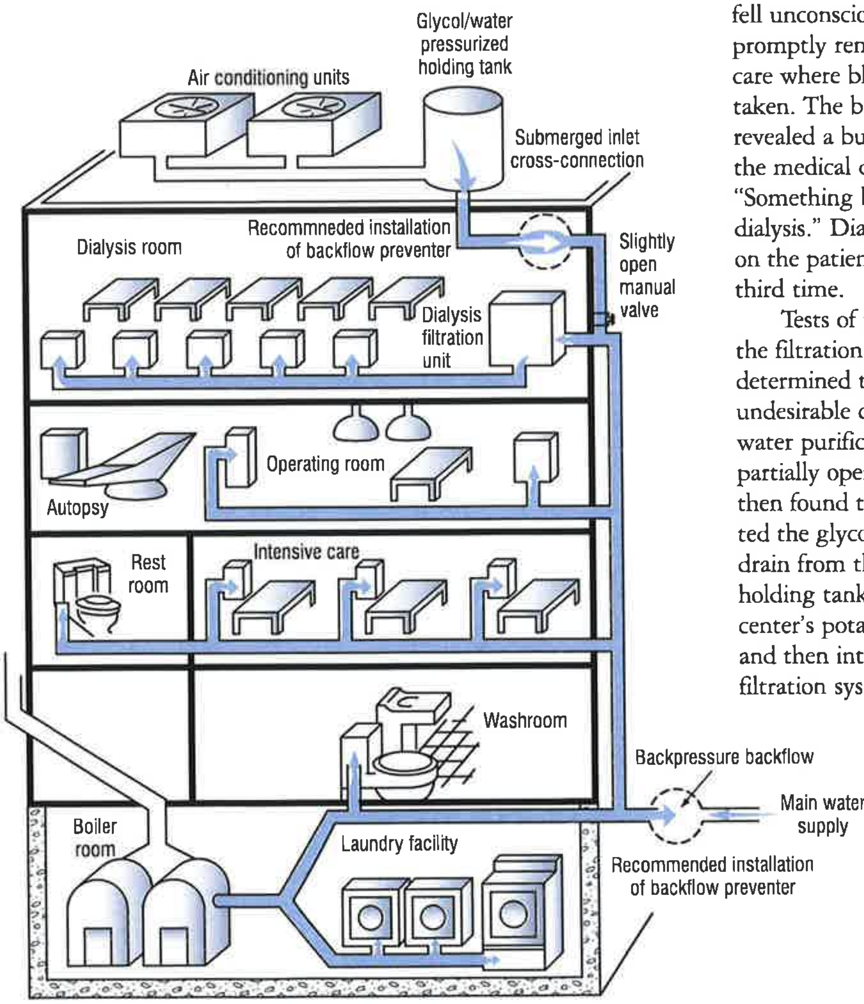
Ethylene glycol, an anti-freeze additive to air conditioning cooling tower water, inadvertently entered the potable water supply system in a medical center in Illinois in September, 1982, and two of six dialysis patients succumbed as a direct or indirect result of the contamination.

The glycol was added to the air conditioning water, and the glycol/water mix was stored in a holding tank that was an integral part of the medical center's air conditioning cooling system. Pressurized make-up water to the holding tank was supplied by a medical center potable supply line and fed through a manually operated control valve. With this valve open, or partially open, potable make-up water flowed slowly into the glycol/water mixture in the holding tank until it filled to the point where the pressure in the closed tank equaled the pressure in the potable water supply feed line. As long as the potable feed line pressure was at least equal to, or greater than, the holding tank pressure, no backflow could occur. The stage was set for disaster, however.

It was theorized that someone in the medical center flushed a toilet or turned on a faucet, which in turn dropped the pressure in the potable supply line to the air conditioning holding tank. Since the manually operated fill valve was partially open, this allowed the glycol/water mixture to enter the medical center potable pipelines and flow into the dialysis equipment. The dialysis filtration system takes out trace chemicals such as those used in the city water treatment plant, but the system could not handle the heavy load of chemicals that it was suddenly subjected to.

The effect upon the dialysis patients was dramatic: patients became drowsy, confused and fell unconscious, and were promptly removed to intensive care where blood samples were taken. The blood samples revealed a build-up of acid and the medical director stated that, "Something has happened in dialysis." Dialysis was repeated on the patients a second and third time.

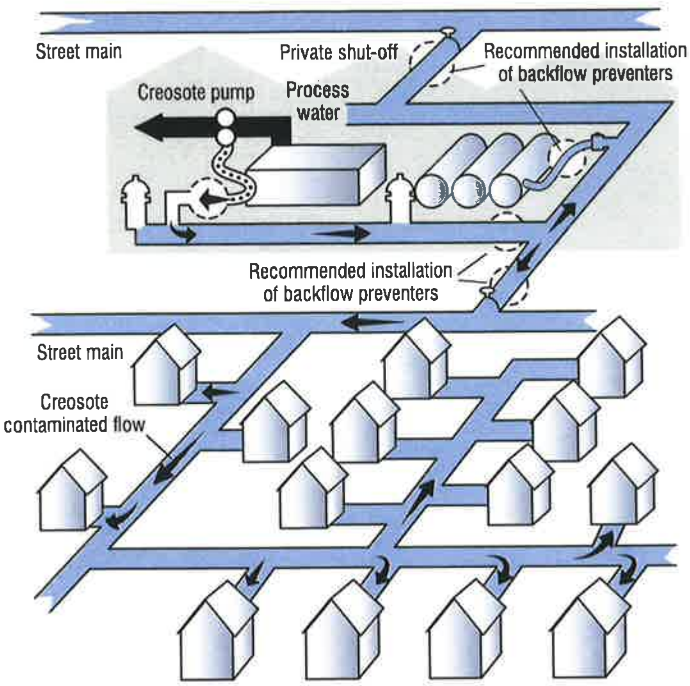
Tests of the water supply to the filtration system quickly determined the presence of "an undesirable chemical in the water purification system." The partially open fill valve was then found that it had permitted the glycol water mix to drain from the air conditioning holding tank into the medical center's potable supply lines and then into the dialysis filtration system equipment.



Creosote in the Water Mains

Creosote entered the water distribution system of a southeastern county water authority in Georgia, in November, 1984, as a result of cross-connection between a ¾-inch hose that was being used as a priming line between a fire service connection and the suction side of a creosote pump. The hose continually supplied water to the pump to ensure the pump was primed at all times. However, while repairs were being made to a private fire hydrant, the creosote back-siphoned into the water mains and contaminated a section of the water distribution system.

Detailed investigation of the cause of the incident disclosed that the wood preservative company, as part of their operation, pumped creosote from collective pits to other parts of their operation. The creosote pump would automatically shut off when the creosote in the pit was lowered to a predetermined level. After the creosote returned to a higher level, the pump would restart. This pump would lose its prime quite often prior to the pit refilling, and to prevent the loss of prime, the wood preservative company would connect a hose from a ¾-inch hose bibb, located on the fire service line, to the suction side of the pump. The hose bibb remained open at all times in an effort to continuously keep the pump primed.

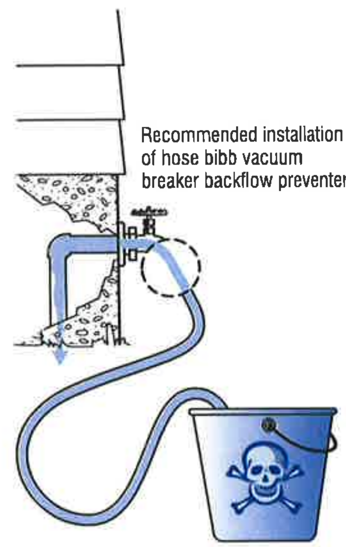


Repairs were necessary to one of the private fire hydrants on the wood preservative company property, necessitating the shutting down of one of two service lines and removal of the damaged fire hydrant for repair. Since the hydrant was at a significantly lower level than the creosote pit, the creosote back-siphoned through a ¾-inch pump priming hose connecting the creosote pit to the fire service line.

After the repairs were made to the hydrant, and the water service restored, the creosote, now in the fire lines, was forced into the main water distribution system.

Kool-Aid Laced With Chlordane

In August, 1978, a professional exterminator was treating a church located in a small town in South Carolina, for termite and pest control. The highly toxic insecticide chlordane was being mixed with water in small buckets, and garden hoses were left submerged in the buckets while the mixing was being accomplished. At the same time, water department personnel came by to disconnect the parsonage's water line from the church to install a separate water meter for the parsonage. In the process, the water was shut off in the area of the church building. Since the church was located on a steep hill, and as the remaining water in the lines was used by residents in the area, the church was among the first places to experience a negative pressure. The chlordane was quickly siphoned into the water lines within the church and became mixed with the Kool-Aid being prepared by women for the vacation bible school. Approximately a dozen children and three adults experienced dizziness and nausea. Fortunately, none required hospitalization or medical attention.



Theory of Backflow and Backsiphonage

A cross-connection[1] is the link or channel connecting a source of pollution with a potable water supply. The polluting substance, in most cases a liquid, tends to enter the potable supply if the net force acting upon the liquid acts in the direction of the potable supply. Two factors are therefore essential for backflow. First, there must be a link between the two systems. Second, the resultant force must be toward the potable supply.

An understanding of the principles of backflow and backsiphonage requires an understanding of the terms frequently used in their discussion. *Force,* unless completely resisted, will produce motion. Weight is a type of force resulting from the earth's gravitational attraction. Pressure (P) is a force-per-unit area, such as pounds per square inch (psi). *Atmospheric pressure* is the pressure exerted by the weight of the atmosphere above the earth.

Pressure may be referred to using an absolute scale, pounds per square inch absolute (psia), or gage scale, pounds per square inch gage (psig). Absolute pressure and gage pressure are related. Absolute pressure is equal to the gage pressure plus the atmospheric pressure. At sea level the atmospheric pressure is 14.7 psia. Thus,

$$P_{absolute} = P_{gage} + 14.7\text{psi}$$

or

$$P_{gage} = P_{absolute} - 14.7\text{ psi}$$

In essence then, absolute pressure is the total pressure. Gage pressure is simply the pressure read on a gage. If there is no pressure on the gage other than atmospheric, the gage would read zero. Then the absolute pressure would be equal to 14.7 psi which is the atmospheric pressure.

The term *vacuum* indicates that the absolute pressure is less than the atmospheric pressure and that the gage pressure is negative. A complete or total vacuum would mean a pressure of 0 psia or -14.7 psig. Since it is impossible to produce a total vacuum, the term vacuum, as used in the text, will mean all degrees of partial vacuum. In a partial vacuum, the pressure would range from slightly less than 14.7 psia (0 psig) to slightly greater than 0 psia (-14.7 psig).

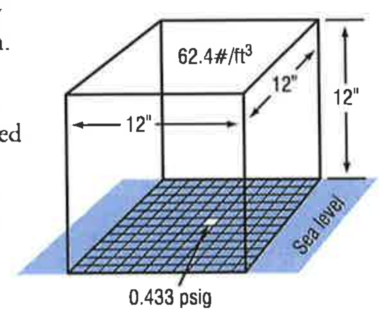
Backsiphonage[1] results in fluid flow in an undesirable or reverse direction. It is caused by atmospheric pressure exerted on a pollutant liquid forcing it toward a potable water supply system that is under a vacuum. Backflow, although literally meaning any type of reversed flow, refers to the flow produced by the differential pressure existing between two systems both of which are at pressures greater than atmospheric.

Water Pressure

For an understanding of the nature of pressure and its relationship to water depth, consider the pressure exerted on the base of a cubic foot of water at sea level. (See Fig. 1) The average weight of a cubic foot of water is 62.4 pounds per square foot gage. The base may be subdivided into 144-square inches with each subdivision being subjected to a pressure of 0.433 psig.

Suppose another cubic foot of water were placed directly on top of the first (See Fig. 2). The pressure on the top surface of the first cube which was originally atmospheric, or 0 psig, would now be 0.433 psig as a result of the superimposed cubic foot of water. The pressure of the base of the first cube would also be increased by the same amount of 0.866 psig, or two times the original pressure.

FIGURE 1.
Pressure exerted by 1 foot of water at sea level.

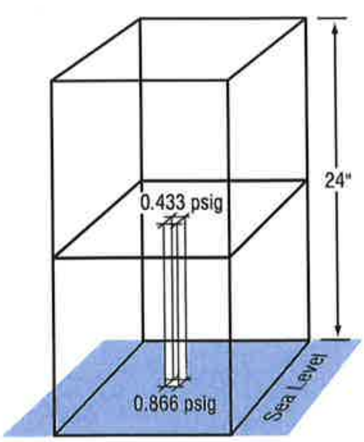


[1]See formal definition in the glossary of the appendix

If this process were repeated with a third cubic foot of water, the pressures at the base of each cube would be 1,299 psig, 0.866 psig, and 0.433 psig, respectively. It is evident that pressure varies with depth below a free water surface; in general each foot of elevation change, within a liquid, changes the pressure by an amount equal to the weight-per-unit area of 1 foot of the liquid. The rate of increase for water is 0.433 psi per foot of depth.

Frequently water pressure is referred to using the terms "pressure head" or just "head," and is expressed in units of feet of water. One foot of head would be equivalent to the pressure produced at the base of a column of water 1 foot in depth. One foot of head or 1 foot of water is equal to 0.433 psig. One hundred feet of head is equal to 43.3 psig.

FIGURE 2.
Pressure exerted by 2 feet of water at sea level.

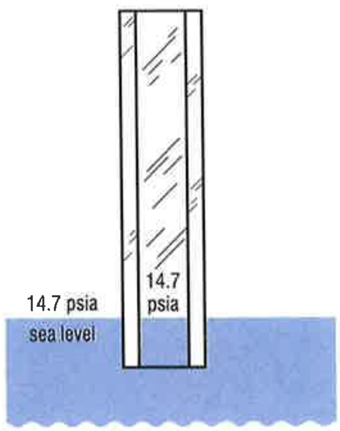


[1]See formal definition in the glossary of the appendix

Siphon Theory

Figure 3 depicts the atmospheric pressure on a water surface at sea level. An open tube is inserted vertically into the water; atmospheric pressure, which is 14.7 psia, acts equally on the surface of the water within the tube and on the outside of the tube.

FIGURE 3.
Pressure on the free surface of a liquid at sea level.



If, as shown in Figure 4, the tube is slightly capped and a vacuum pump is used to evacuate all the air from the sealed tube, a vacuum with a pressure of 0 psia is created within the tube. Because the pressure at any point in a static fluid is dependent upon the height of that point above a reference line, such as sea level, it follows that the pressure within the tube at sea level must still be 14.7 psia. This is equivalent to the pressure at the base of a column of water 33.9 feet high and with the column open at the base, water would rise to fill the column to a depth of 33.9 feet. In other words, the weight of the atmosphere at sea level exactly balances the weight of a column of water 33.9 feet in height. The absolute pressure within the column of water in Figure 4 at a height of 11.5 feet is equal to 9.7 psia. This is a partial vacuum with an equivalent gage pressure of -5.0 psig.

As a practical example, assume the water pressure at a closed faucet on the top of a 100-foot high building to be 20 psig; the pressure on the ground floor would then be 63.3 psig. If the pressure at the ground were to drop suddenly due to a heavy fire demand in the area to 33.3 psig, the pressure at the top would be reduced to -10 psig. If the building water system were airtight, the water would remain at the level of the faucet because of the partial vacuum created by the drop in pressure. If the faucet were opened, however, the vacuum would be broken and the water level would drop to a height of 77 feet above the ground. Thus, the atmosphere was supporting a column of water 23 feet high.

FIGURE 4.
Effect of evacuating air from a column.

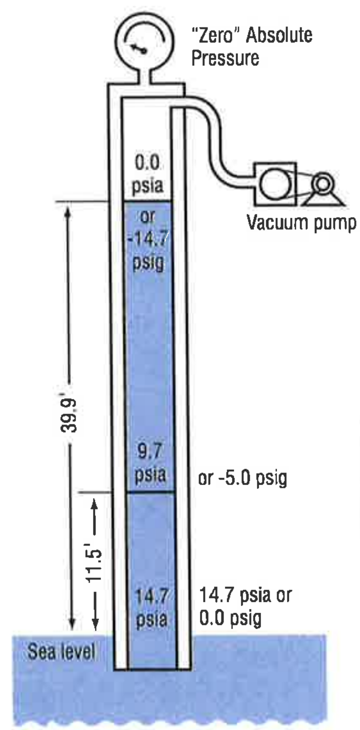
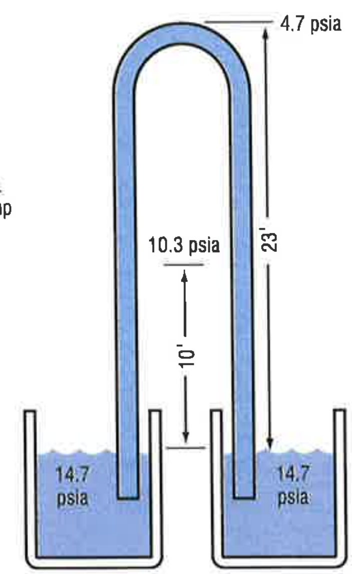


Figure 5 is a diagram of an inverted U-tube that has been filled with water and placed in two open containers at sea level.

If the open containers are placed so that the liquid levels in each container are at the same height, a static state will exist; and the pressure at any specified level in either leg of the U-tube will be the same.

The equilibrium condition is altered by raising one of the containers so that the liquid level in one container is 5 feet

FIGURE 5.
Pressure relationships in a continuous fluid system at the same elevation.



above the level of the other. (See Fig. 6.) Since both containers are open to the atmosphere, the pressure on the liquid surfaces in each container will remain at 14.7 psia.

If it is assumed that a static state exists, momentarily, within the system shown in Figure 6, the pressure in the left tube at any height above the free surface in the left container can be calculated. The pressure at the corresponding level in the right tube above the free surface in the right container may also be calculated.

As shown in Figure 6, the pressure at all levels in the left tube would be less than at corresponding levels in the right tube. In this case, a static condition cannot exist because fluid will flow from the higher pressure to the lower pressure; the flow would be from the right tank to the left tank. This arrangement will be recognized as a siphon. The crest of a siphon cannot be higher than 33.9 feet above the upper liquid level, since atmosphere cannot support a column of water greater in height than 33.9 feet.

Figure 7 illustrates how this siphon principle can be hazardous in a plumbing system. If the supply valve is closed, the pressure in the line supplying the faucet is less than the pressure in the supply line to the bathtub. Flow will occur, therefore, through siphonage, from the bathtub to the open faucet.

FIGURE 6.
Pressure relationships in a continuous fluid system at different elevations.

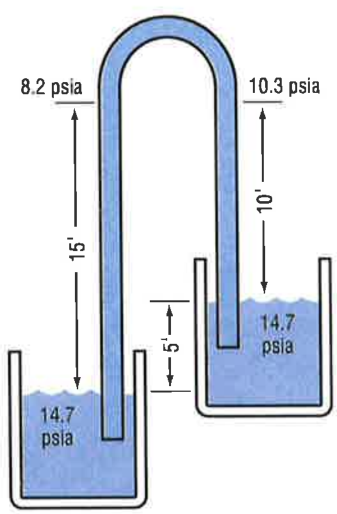
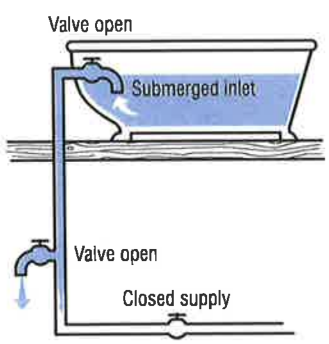


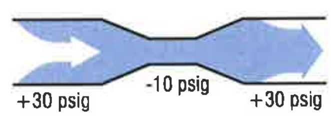
FIGURE 7.
Backsiphonage in a plumbing system.



The siphon actions cited have been produced by reduced pressures resulting from a difference in the water levels at two separated points within a continuous fluid system.

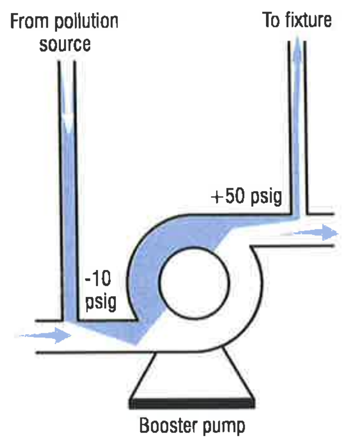
Reduced pressure may also be created within a fluid system as a result of fluid motion. One of the basic principles of fluid mechanics is the principle of conservation of energy. Based upon this principle, it may be shown that as a fluid accelerates, as shown in Figure 8, the pressure is reduced. As water flows through a constriction such as a converging section of pipe, the velocity of the water increases; as a result, the pressure is reduced. Under such conditions, negative pressures may be developed in a pipe. The simple aspirator is based upon this principle. If this point of reduced pressure is linked to a source of pollution, backsiphonage of the pollutant can occur.

FIGURE 8.
Negative pressure created by constricted flow.



One of the common occurrences of dynamically reduced pipe pressures is found on the suction side of a pump. In many cases similar to the one illustrated in Figure 9, the line supplying the booster pump is undersized or does not have sufficient pressure to deliver water at the rate at which the pump normally operates. The rate of flow in the pipe may be increased by a further reduction in pressure at the pump intake. This often results in the creation of negative pressure at the pump intake. This often results in the creation of negative pressure. This negative pressure may become low enough in some cases to cause vaporization of the water in the line. Actually, in the illustration shown,

FIGURE 9.
Dynamically reduced pipe pressures.



flow from the source of pollution would occur when pressure on the suction side of the pump is less than pressure of the pollution source; but this is *backflow,* which will be discussed below.

The preceding discussion has described some of the means by which negative pressures may be created and which frequently occur to produce backsiphonage. In addition to the negative pressure or reversed force necessary to cause backsiphonage and backflow, there must also be the cross-connection or connecting link between the potable water supply and the source of pollution. Two basic types of connections may be created in piping systems. These are the solid pipe with valved connection and the *submerged inlet.*

Figures 10 and 11 illustrate solid connections. This type of connection is often installed where it is necessary to supply an auxiliary piping system from the potable source. It is a direct connection of one pipe to another pipe or receptacle.

Solid pipe connections are often made to continuous or intermittent waste lines where it is assumed that the flow will be in one direction only. An example of this would be used cooling water from a water jacket or condenser as shown in Figure 11. This type of connection is usually detectable but creating a concern on the part of the installer about the possibility of reversed flow is often more difficult. Upon questioning, however, many installers will agree that the solid connection was made because the sewer is occasionally subjected to backpressure.

FIGURE 10.
Valved connections between potable water and nonpotable fluid.

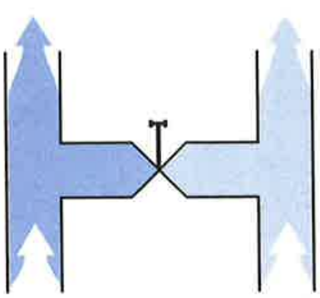
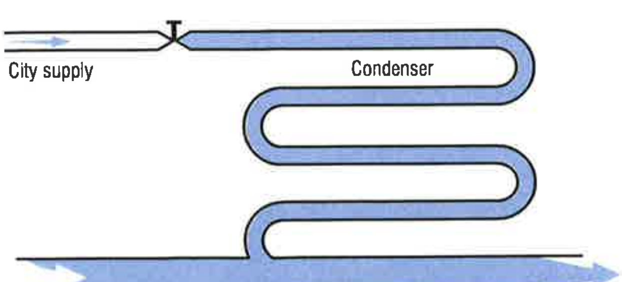


FIGURE 11
Valved connection between potable water and sanitary sewer.



Submerged inlets are found on many common plumbing fixtures and are sometimes necessary features of the fixtures if they are to function properly. Examples of this type of design are siphon-jet urinals or water closets, flushing rim slop sinks, and dental cuspidors. Oldstyle bathtubs and lavatories had supply inlets below the flood level rims, but modern sanitary design has minimized or eliminated this hazard in new fixtures. Chemical and industrial process vats sometimes have submerged inlets where the water pressure is used as an aid in diffusion, dispersion and agitation of the vat contents. Even though the supply pipe may come from the floor above the vat, backsiphonage can occur as it has been shown that the siphon action can raise a liquid such as water almost 34 feet. Some submerged inlets difficult to control are those which are not apparent until a significant change in water level occurs or where a supply may be conveniently extended below the liquid surface by means of a hose or auxiliary piping. A submerged inlet may be created in numerous ways, and its detection in some of these subtle forms may be difficult.

The illustrations included in part B of the appendix are intended to describe typical examples of backsiphonage, showing in each case the nature of the link or cross-connection, and the cause of the negative pressure.

Backflow

Backflow[1], as described in this manual, refers to reversed flow due to backpressure other than siphonic action. Any interconnected fluid systems in which the pressure of one exceeds the pressure of the other may have flow from one to the other as a result of the pressure differential. The flow will occur from the zone of higher pressure to the zone of lower pressure. This type of backflow is of concern in buildings where two or more piping systems are maintained. The potable water supply is usually under pressure directly from the city water main. Occasionally, a booster pump is used. The auxiliary system is often pressurized by a centrifical pump, although backpressure may be caused by gas or steam pressure from a boiler. A reversal in differential pressure may occur when pressure in the potable system drops, for some reason, to a pressure lower than that in the system to which the potable water is connected.

The most positive method of avoiding this type of backflow is the total or complete separation of the two systems. Other methods used involve the installation of mechanical devices. All methods require routine inspection and maintenance.

Dual piping systems are often installed for extra protection in the event of an emergency or possible mechanical failure of one of the systems. Fire protection systems are an example. Another example is the use of dual water connections to boilers. These installations are sometimes interconnected, thus creating a health hazard.

The illustrations in part C of the appendix depict installations where backflow under pressure can occur, describing the cross-connection and the cause of the reversed flow.

[1]See formal definition in the glossary of the appendix

Methods and Devices for the Prevention of Backflow and Back-Siphonage

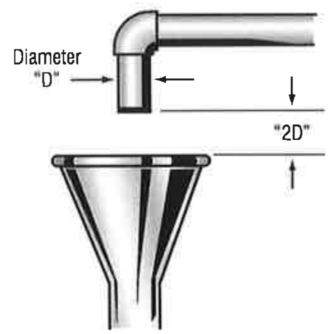
A wide choice of devices exists that can be used to prevent backsiphonage and backpressure from adding contaminated fluids or gases into a potable water supply system. Generally, the selection of the proper device to use is based upon the degree of hazard posed by the cross-connection. Additional considerations are based upon piping size, location, and the potential need to periodically test the devices to insure proper operation.

There are six basic types of devices that can be used to correct cross-connections: air gaps, barometric loops, vacuum breakers—both atmospheric and pressure type, double check with intermediate atmospheric vent, double check valve assemblies, and reduced pressure principle devices. In general, all manufacturers of these devices, with the exception of the barometric loop, produce them to one or more of three basic standards, thus insuring the public that dependable devices are being utilized and marketed. The major standards in the industry are: American Society of Sanitary Engineers ASSE), American Water Works Association (AWWA), and the University of California Foundation for Cross-Connection Control and Hydraulic Research.

Air Gap

Air gaps are non-mechanical backflow preventers that are very effective devices to be used where either backsiphonage or backpressure conditions may exist. Their use is as old as piping and plumbing itself, but only relatively recently have standards been issued that standardize their design. In general, the air gap must be twice the supply pipe diameter but never less than one inch. See Figure 12.

FIGURE 12.
Air gap.



An air gap, although an extremely effective backflow preventer when used to prevent backsiphonage and backpressure conditions, does interrupt the piping flow with corresponding loss of pressure for subsequent use. Consequently, air gaps are primarily used at end of the line service where reservoirs or storage tanks are desired. When contemplating the use of an air gap, some other considerations are:

(1) In a continuous piping system, each air gap requires the added expense of reservoirs and secondary pumping systems.

(2) The air gap may be easily defeated in the event that the "2D" requirement was purposely or inadvertently compromised. Excessive splash may be encountered in the event that higher than anticipated pressures or flows occur. The splash may be a cosmetic or true potential hazard—the simple solution being to reduce the "2D" dimension by thrusting the supply pipe into the receiving funnel. By so doing, the air gap is defeated.

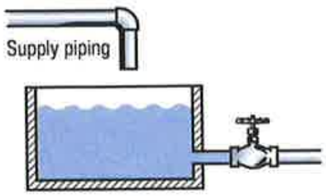
(3) At an air gap, we expose the water to the surrounding air with its inherent bacteria, dust particles, and other airborne pollutants or contaminants. In addition, the aspiration effect of the flowing water can drag down surrounding pollutants into the reservoir or holding tank.

(4) Free chlorine can come out of treated water as a result of the air gap and the resulting splash and churning effect as the water enters the holding tanks. This reduces the ability of the water to withstand bacteria contamination during long term storage.

(5) For the above reasons, air gaps must be inspected as frequently as mechanical backflow preventers. They are not exempt from an in-depth cross-connection control program requiring periodic inspection of all backflow devices.

Air gaps may be fabricated from commercially available plumbing components or purchased as separate units and integrated into plumbing and piping systems. An example of the use of an air gap is shown in Figure 13.

FIGURE 13.
Air gap in a piping system.



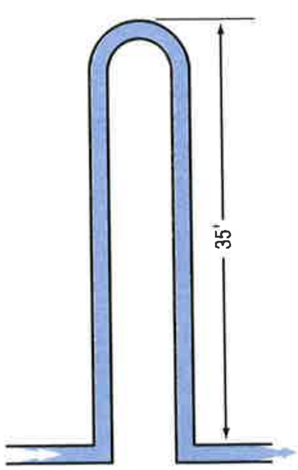
Barometric Loop

The barometric loop consists of a continuous section of supply piping that abruptly rises to a height of approximately 35 feet and then returns back down to the originating level. It is a loop in the piping system that effectively protects against backsiphonage. It may not be used to protect against back-pressure.

Its operation, in the protection against back-siphonage, is based upon the principle that a water column, at sea level pressure, will not rise above 33.9 feet (Ref. Chapter 3, Fig. 4 Page 13).

In general, barometric loops are locally fabricated, and are 35 feet high.

FIGURE 14.
Barometric loop.



Atmospheric Vacuum Breaker

These devices are among the simplest and least expensive mechanical types of backflow preventers and, when installed properly, can provide excellent protection against back-siphonage. They must not be utilized to protect against backpressure conditions. Construction consists usually of a polyethylene float which is free to travel on a shaft and seal in the uppermost position against atmosphere with an elastomeric disc. Water flow lifts the float, which then causes the disc to seal. Water pressure keeps the float in the upward sealed position. Termination of the water supply will cause the disc to drop down venting the unit to atmosphere and thereby opening downstream piping to atmospheric pressure, thus preventing backsiphonage. Figure 15 shows a typical atmospheric breaker.

In general, these devices are available in ½-inch through 3-inch size and must be installed vertically, must not have shutoffs downstream, and must be installed at least 6-inches higher than the final outlet. They cannot be tested once they are installed in the plumbing system, but are, for the most part, dependable, trouble-free devices for backsiphonage protection.

FIGURE 15.
Atmospheric vacuum breaker.

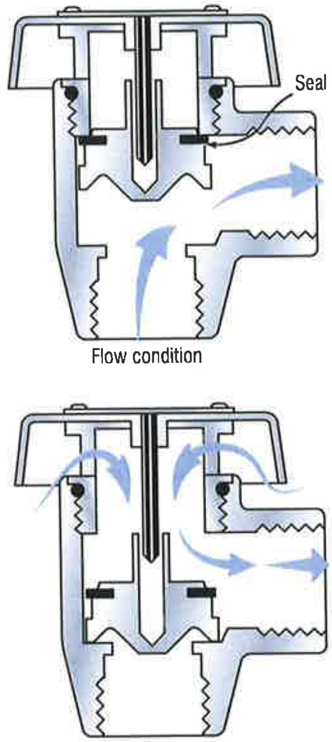


Figure 16 shows the generally accepted installation requirements—note that no shutoff valve is downstream of the device that would otherwise keep the atmospheric vacuum breaker under constant pressure.

Figure 17 shows a typical installation of an atmospheric vacuum breaker in a plumbing supply system.

FIGURE 16.
Atmospheric vacuum breaker typical installation.

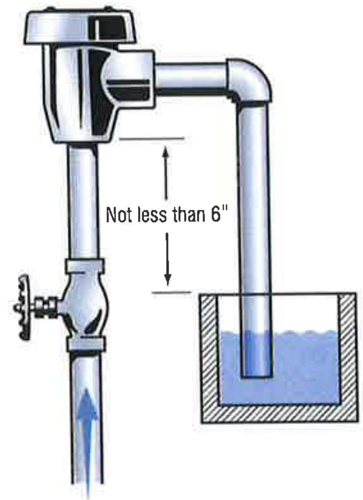


FIGURE 17.
Atmospheric vacuum breaker in plumbing supply system.

Hose Bibb Vacuum Breakers

These small devices are a specialized application of the atmospheric vacuum breaker. They are generally attached to sill cocks and in turn are connected to hose supplied outlets such as garden hoses, slop sink hoses, spray outlets, etc. They consist of a spring loaded check valve that seals against an atmospheric outlet when water supply pressure is turned on. Typical construction is shown in Figure 18.

When the water supply is turned off, the device vents to atmosphere, thus protecting against backsiphonage conditions. They should not be used as backpressure devices. Manual drain options are available, together with tamper-proof versions. A typical installation is shown in Figure 19.

FIGURE 18.
Hose bibb vacuum breaker.

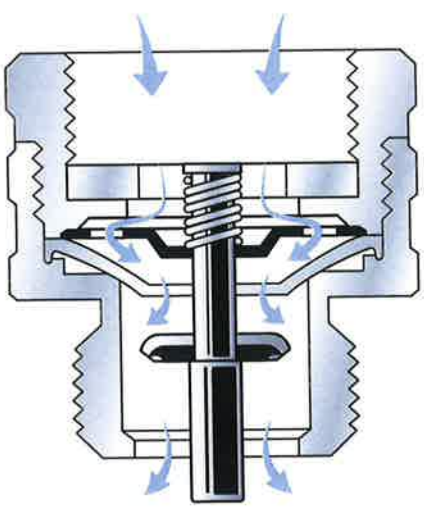
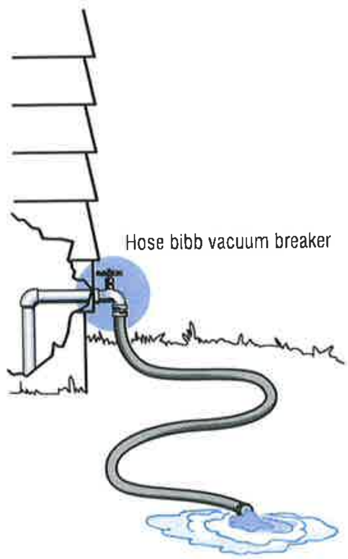


FIGURE 19.
Typical installation of hose bibb vacuum breaker.



Pressure Vacuum Breakers

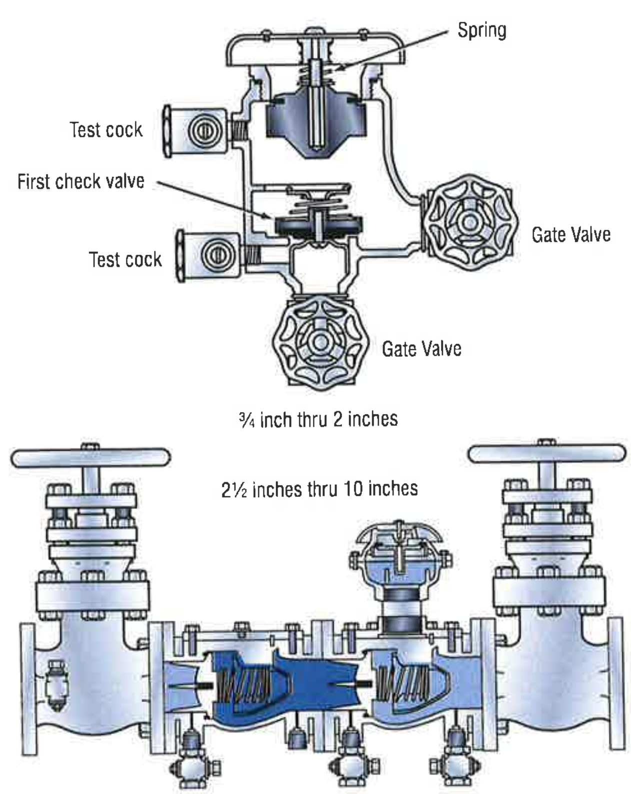
This device is an outgrowth of the atmospheric vacuum breaker and evolved in response to a need to have an atmospheric vacuum breaker that could be utilized under constant pressure and that could be tested in line. A spring on top of the disc and float assembly, two added gate valves, test cocks, and an additional first check, provided the answer to achieve this device. See Figure 20.

These units are available in the general configurations as shown in Figure 20 in sizes ½-inch through 10-inch and have broad usage in the agriculture and irrigation market. Typical agricultural and industrial applications are shown in Figure 21.

Again, these devices may be used under constant pressure but do not protect against backpressure conditions. As a result, installation must be at least 6- to 12-inches higher than the existing outlet.

A spill resistant pressure vacuum breaker (SVB) is available that is a modification to the standard pressure vacuum breaker but specifically designed to minimize water spillage. Installation and hydraulic requirements are similar to the standard pressure vacuum breaker and the devices are recommended for internal use.

FIGURE 20.
Pressure vacuum breaker



Double Check with Intermediate Atmospheric Vent

The need to provide a compact device in ½-inch and ¾-inch pipe sizes that protects against moderate hazards, is capable of being used under constant pressure and that protects against backpressure, resulted in this unique backflow preventer. Construction is basically a double check valve having an atmospheric vent located between the two checks (See Figure 22).

Line pressure keeps the vent closed, but zero supply pressure or backsiphonage will open the inner chamber to atmosphere. With this device, extra protection is obtained through the atmospheric vent capability. Figure 23 shows a typical use of the device on a residential boiler supply line.

FIGURE 21.
Typical agricultural and industrial application of pressure vacuum breaker.

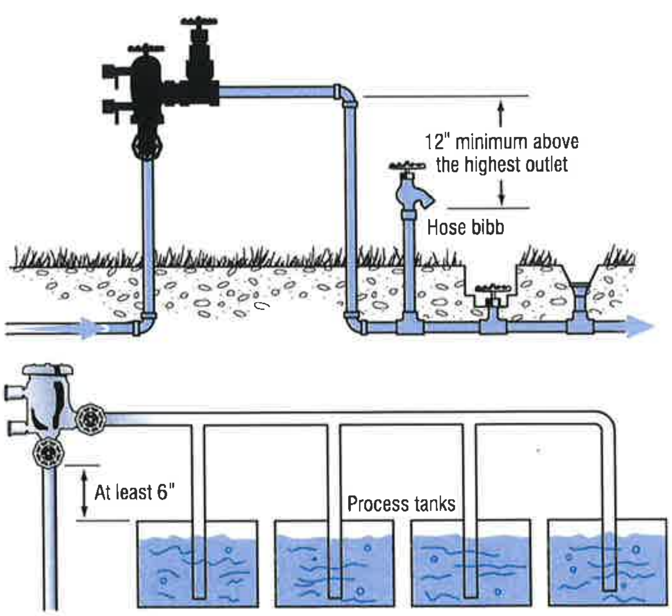


FIGURE 22.
Double check valve with atmospheric vent.

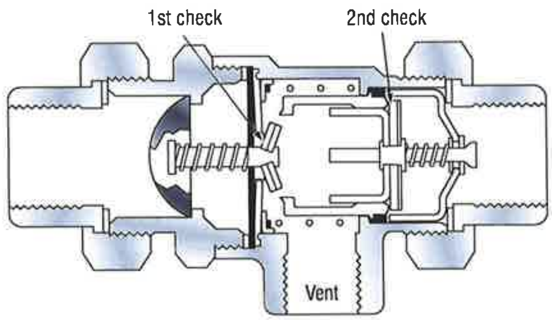
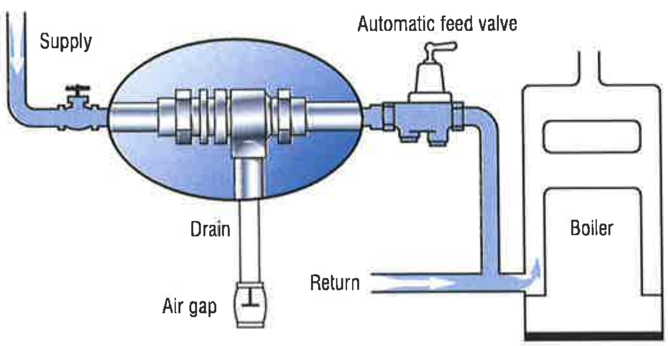


FIGURE 23.
Typical residential use of double check with atmospheric vent.



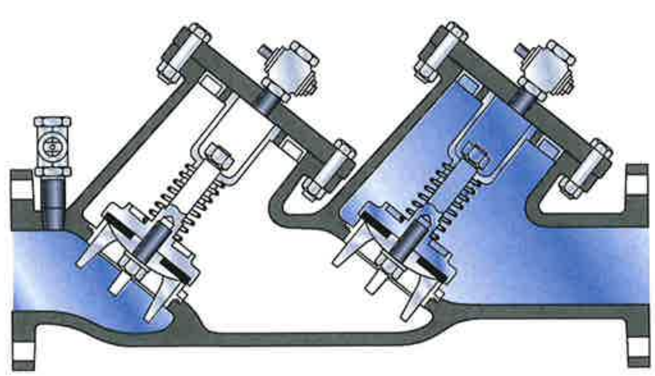
Double Check Valve

A double check valve is essentially two single check valves coupled within one body and furnished with test cocks and two tightly closing gate valves (See Figure 24).

The test capability feature gives this device a big advantage over the use of two independent check valves in that it can be readily tested to determine if either or both check valves are inoperative or fouled by debris. Each check is spring loaded closed and requires approximately a pound of pressure to open.

This spring loading provides the ability to "bite" through small debris and still seal—a protection feature not prevalent in unloaded swing check valves. Figure 24 shows a cross section of double check valve complete with test cocks. Double checks are commonly used to protect against low to medium hazard installations such as food processing steam kettles and apartment projects. They may be used under continuous pressure and protect against both backsiphonage and backpressure conditions.

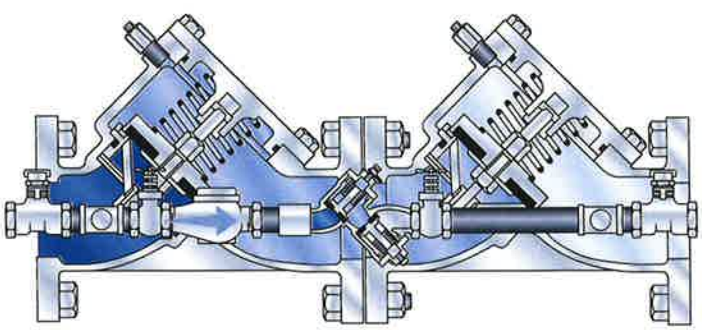
FIGURE 24.
Double check valve.



Double Check Detector Check

This device is an outgrowth of the double check valve and is primarily utilized in fire line installations. Its purpose is to protect the potable supply line from possible contamination or pollution from fire line chemical additives, booster pump fire line backpressure, stagnant "black water" that sits in fire lines over extended periods of time, the addition of "raw" water through outside fire pumper connections (Siamese outlets), and the detection of any water movement in the fire line water due to fire line leakage or deliberate water theft. It consists of two, spring loaded check valves, a bypass assembly with water meter and double check valve, and two tightly closing gate valves. See Figure 25. The addition of test cocks makes the device testable to insure proper operation of both the primary checks and the bypass check valve. In the event of very low fire line water usage, (theft of water) the low pressure drop inherent in the bypass system permits the low flow of water to be metered through the bypass system. In a high flow demand, associated with deluge fire capability, the main check valves open, permitting high volume, low restricted flow, through the two large spring loaded check valves.

FIGURE 25.
Double check detector check.



Residential Dual Check

The need to furnish reliable and inexpensive backsiphonage and backpressure protection for individual residences resulted in the debut of the residential dual check. Protection of the main potable supply from household hazards such as home photograph chemicals, toxic insect and garden sprays, termite control pesticides used by exterminators, etc., reinforced, a true need for such a device. Figure 26 shows a cutaway of the device.

It is sized for ½-, ¾-, and 1-inch service lines and is installed immediately downstream of the water meter. The use of plastic check modules and elimination of test cocks and gate valves keeps the cost reasonable while providing good, dependable protection. Typical installations are shown in Figures 27 and 28.

FIGURE 26.
Residential dual check.

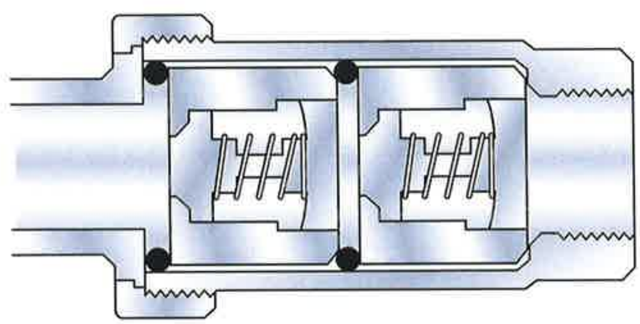


FIGURE 27.
Residential installation.

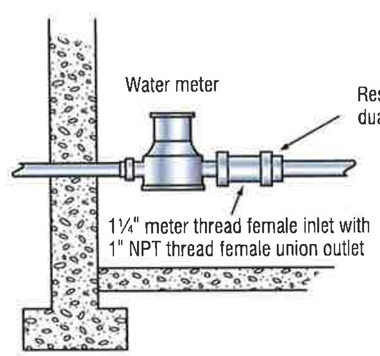
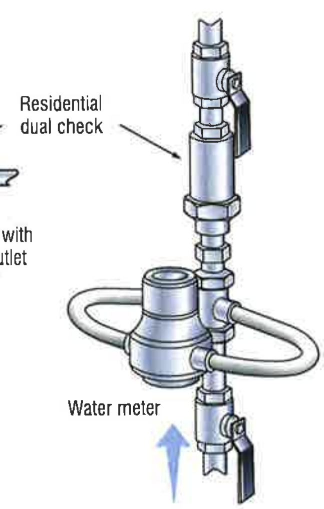


FIGURE 28.
Copper horn.



Reduced Pressure Principle Backflow Preventer

Maximum protection is achieved against backsiphonage and backpressure conditions utilizing reduced pressure principle backflow preventers. These devices are essentially modified double check valves with an atmospheric vent capability placed between the two checks and designed such that this "zone" between the two checks is always kept at least two pounds less than the supply pressure. With this design criteria, the reduced pressure principle backflow preventer can provide protection against backsiphonage and backpressure when both the first and second checks become fouled. They can be used under constant pressure and at high hazard installations. They are furnished with test cocks and gate valves to enable testing and are available in sizes ¾-inch through 10 inch.

Figure 29A shows typical devices representative of ¾-inch through 2-inch size and Figure 29B shows typical devices representative of 2½-inch through 10-inch sizes.

FIGURE 29A.
Reduced pressure zone backflow preventer (¾-inch thru 2-inches).

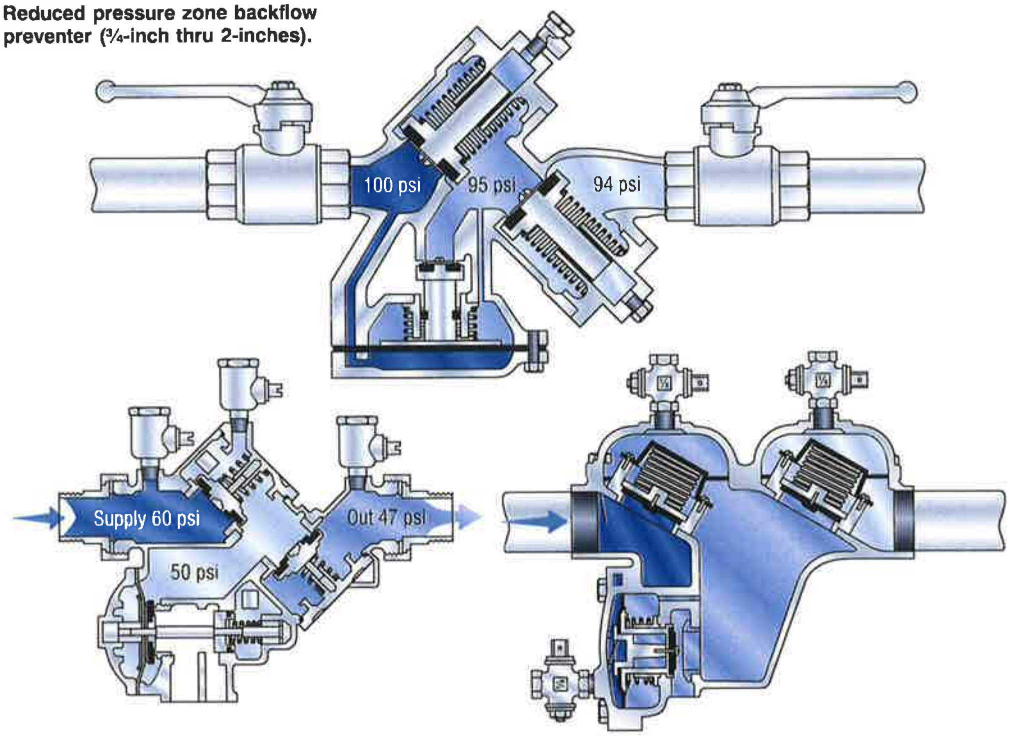
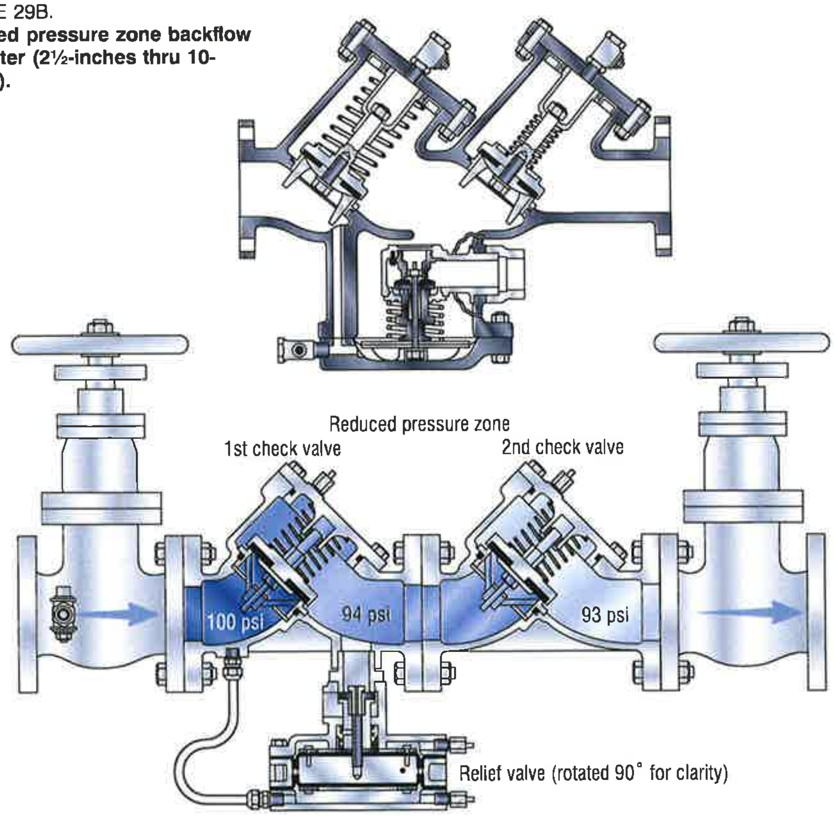


FIGURE 29B.
Reduced pressure zone backflow preventer (2½-inches thru 10-inches).



The principles of operation of a reduced pressure principle backflow preventer are as follows:

Flow from the left enters the central chamber against the pressure exerted by the loaded check valve 1. The supply pressure is reduced thereupon by a predetermined amount. The pressure in the central chamber is maintained lower than the incoming supply pressure through the operation of the relief valve 3, which discharges to the atmosphere whenever the central chamber pressure approaches within a few pounds of the inlet pressure. Check valve 2 is lightly loaded to open with a pressure drop of 1 psi in the direction of flow and is independent of the pressure required to open the relief valve. In the event that the pressure increases downstream from the device, tending to reverse the direction of flow, check valve 2 closes, preventing backflow. Because all valves may leak as a result of wear or obstruction, the protection provided by the check valves is not considered sufficient. If some obstruction prevents check valve 2 from closing tightly, the leakage back into the central chamber would increase the pressure in this zone, the relief valve would open, and flow would be discharged to the atmosphere.

When the supply pressure drops to the minimum differential required to operate the relief valve, the pressure in the central chamber should be atmospheric. If the inlet pressure should become less than atmospheric pressure, relief valve 3 should remain fully open to the atmosphere to discharge any water which may be caused to backflow as a result of backpressure and leakage of check valve 2.

Malfunctioning of one or both of the check valves or relief valve should always be indicated by a discharge of water from the relief port. Under no circumstances should plugging of the relief port be permitted because the device depends upon an open port for safe operation. The pressure loss through the device may be expected to average between 10 and 20 psi within the normal range of operation, depending upon the size and flow rate of the device.

Reduced pressure principle backflow preventers are commonly installed on high hazard installations such as plating plants, where they would protect against primarily backsiphonage potential, car washes where they would protect against backpressure conditions, and funeral parlors, hospital autopsy rooms, etc. The reduced pressure principle backflow preventer forms the backbone of cross-connection control programs. Since it is utilized to protect against high hazard installations, and since high hazard installations are the first consideration in protecting public health and safety, these devices are installed in large quantities over a broad range of plumbing and water works installations. Figures 31 and 32 show typical installations of these devices on high hazard installations.

FIGURE 30.
Reduced pressure zone backflow preventer — principle of operation.

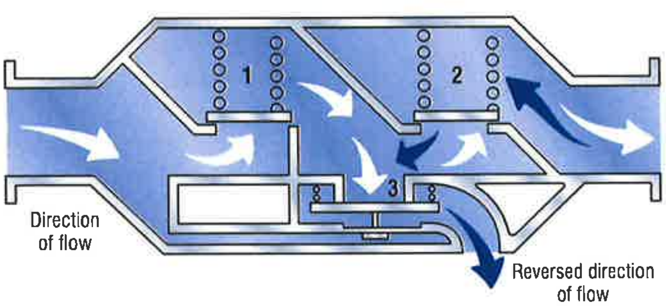


FIGURE 31.
Plating plant installation.

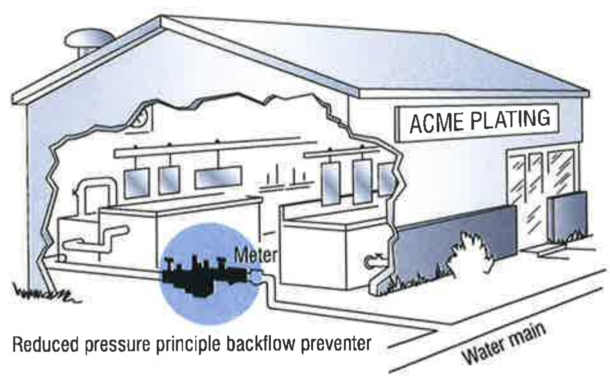


FIGURE 32.
Car wash installation.

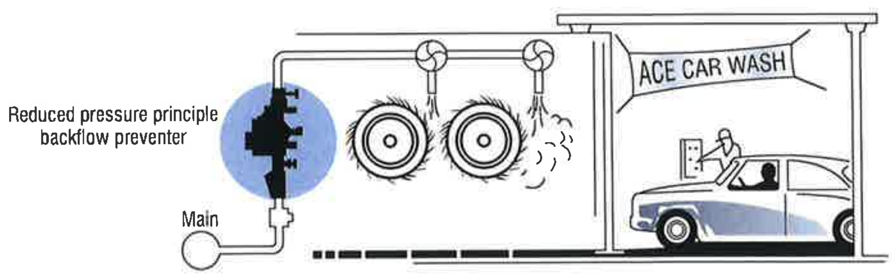
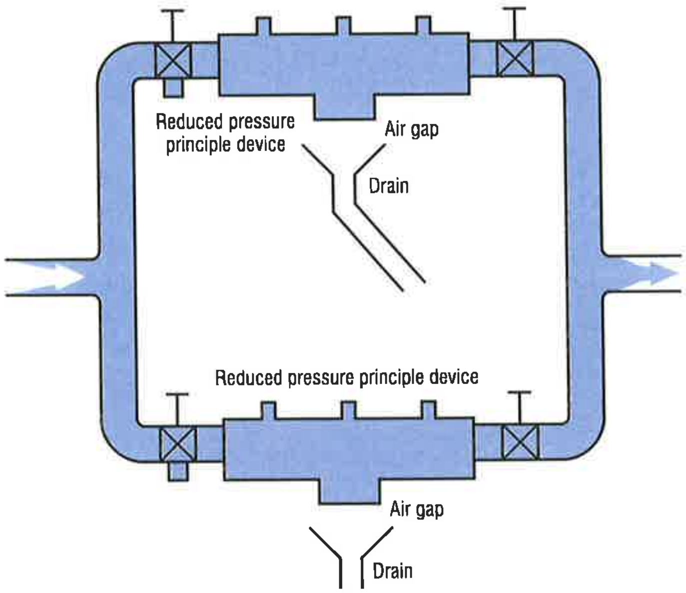


FIGURE 33.
Typical bypass configuration reduced pressure principle devices



Note: Devices to be set a min. of 12" and a max. of 30" from the floor and 12" from any wall.

FIGURE 34.
Typical installation reduced pressure principle device horizontal illustration.

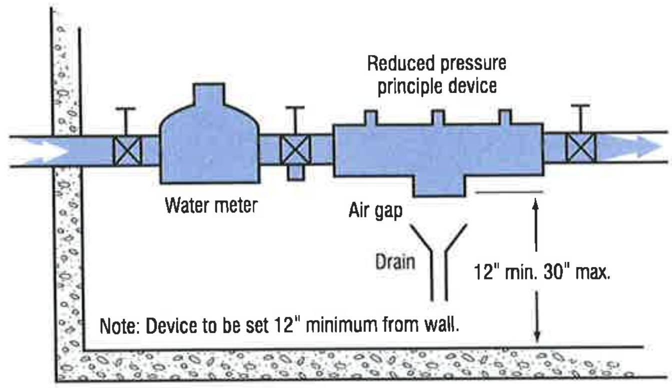
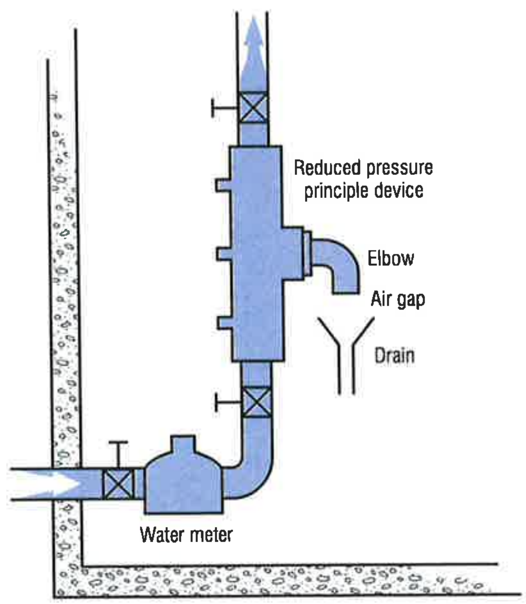


FIGURE 35.
Typical installation reduced pressure principle device vertical illustration.



Note: (1) Refer to manufacturers installation data for vertical mount.
(2) Unit to be set at a height to permit ready access for testing and service.
(3) Vertical installation only to be used if horizontal installation cannot be achieved.

Typical fire line installation double check valve vertical installation.

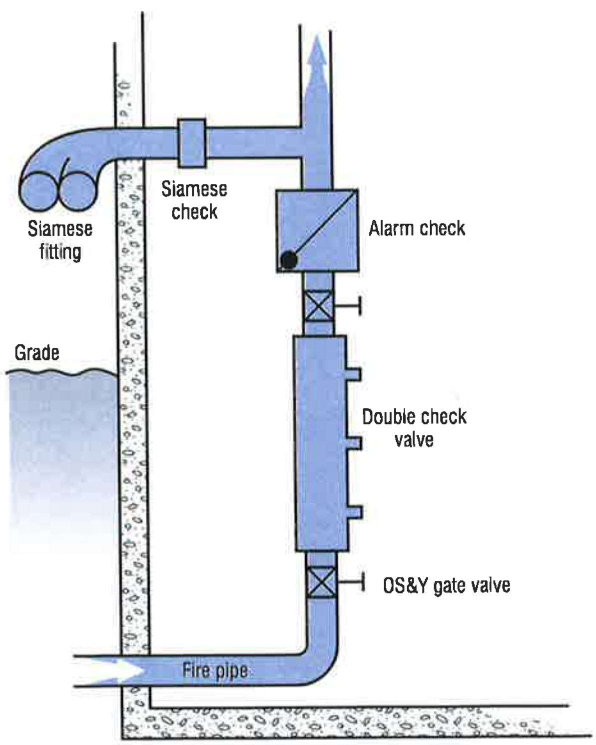
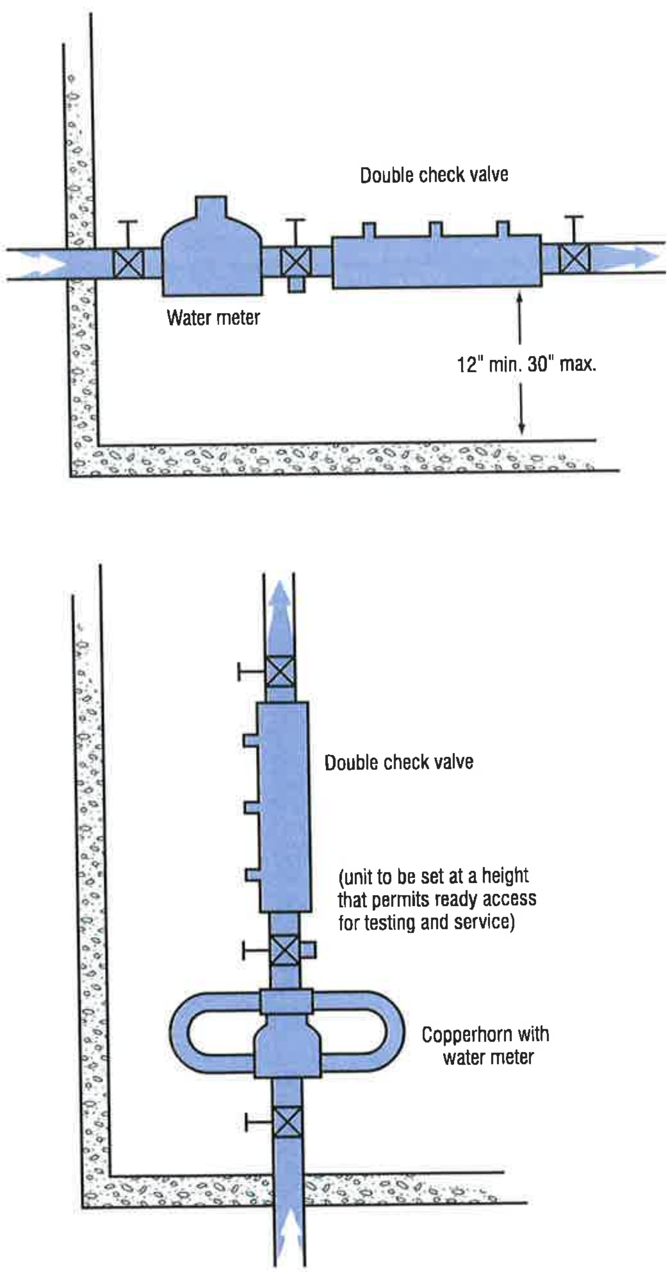
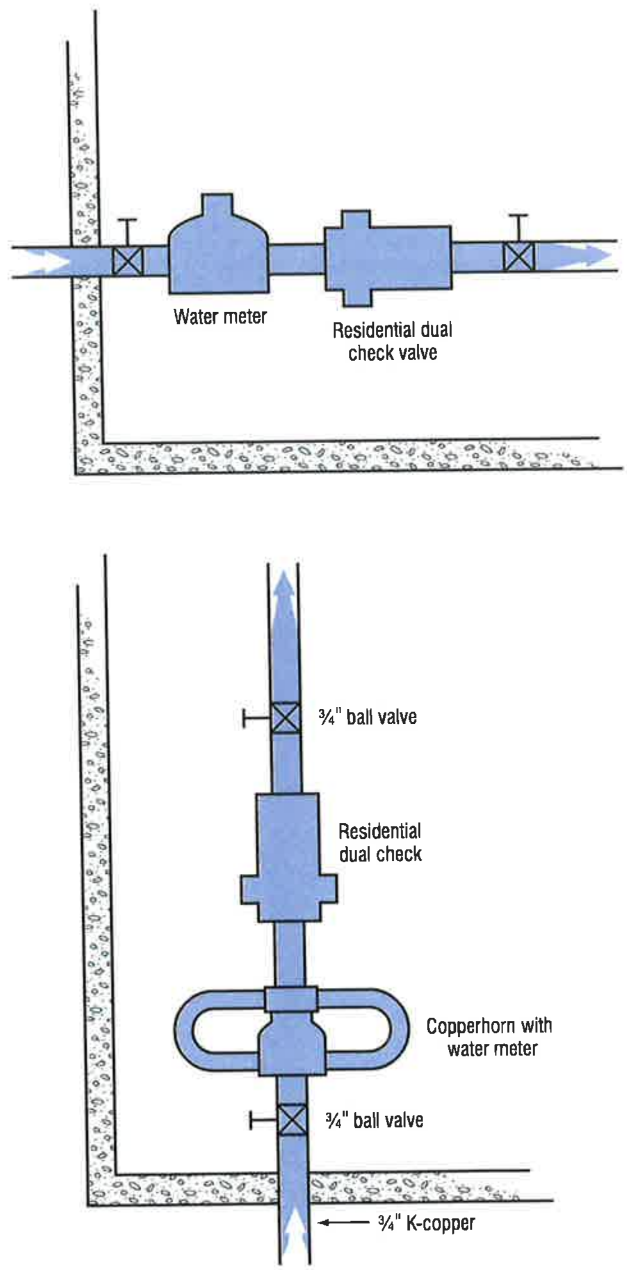


FIGURE 36.
Typical installation double check valve horizontal and vertical installation.



Note: Vertical installation only to be used if horizontal installation cannot be achieved.

FIGURE 37.
Typical installation residential dual check with straight set and copperhorn.



Testing Procedures for Backflow Preventers

Prior to initiating a test of any backflow device, it is recommended that the following procedures be followed:

1. Permission be obtained from the owner, or his representative, to shut down the water supply. This is necessary to insure that since all testing is accomplished under no-flow conditions, the owner is aware that his water supply will be temporarily shut off while the testing is being performed. Some commercial and industrial operations require constant and uninterrupted water supplies for cooling, boiler feed, seal pump water, etc. and water service interruption cannot be tolerated. The water supply to hospitals and continuous process industries cannot be shut off without planned and coordinated shut downs. The request to shut down the water supply is therefore a necessary prerequisite to protect the customer as well as limit the liability of the tester.

Concurrent with the request for permission to shut off the water, it is advisable to point out to the owner, or his representative, that while the water is shut off during the test period, any inadvertent use of water within the building will reduce the water pressure to zero. Backsiphonage could result if unprotected cross-connections existed which would contaminate the building water supply system. In order to address this situation, it is recommended that the owner caution the inhabitants of the building not to use the water until the backflow test is completed and the water pressure restored. Additional options available to the building owner would be the installation of two backflow devices in parallel that would enable a protected bypass flow around the device to be tested. Also, if all water outlets are protected within the building with "fixture outlet protection" backflow devices, cross-connections would not create a problem in the event of potential backsiphonage conditions occurring while devices are tested, or for any other reason.

2. Determine the type of device to be tested i.e., double check valve or reduced pressure principle device.

3. Determine the flow direction. (Reference directional flow arrows or wording provided by the manufacturer on the device.)

4. Number the test cocks, bleed them of potential debris, and assemble appropriate test cock adapters and bushings that may be required.

5. Shut off the downstream (number 2) shut-off valve. (Ref. Item (1) above.)

6. Wait several moments prior to hooking up the test kit hoses when testing a reduced pressure principle device. If water exits the relief valve, in all likelihood, the first check valve is fouled and it is impractical to proceed with the testing until the valve is serviced. This waiting period is not necessary when testing double check valves.

7. Hook up the test kit hoses in the manner appropriate to the device being tested and the specific test being performed.

Test personnel are cautioned to be aware and follow local municipal, county, and state testing requirements and guidelines as may be dictated by local authority. The following test procedures are guidelines for standard, generally acceptable test procedures but may be amended, superceded, or modified by local jurisdiction.

Test Equipment

For field testing of reduced pressure principle backflow preventers and double check valve assemblies, a differential pressure test gauge is utilized having a 0 to 15 psi range and a working pressure of 500 psi. Appropriate length of hoses with necessary fittings accompany the test gauge. Several manufactured test kits are commercially available that incorporate the differential gauge, hoses, and fittings and are packaged for ease of portability and come with protective enclosures or straps for hanging. Calibrated water columns are commercially available that are portable and come with carrying cases.

It is important that all test equipment be periodically checked for calibration.

Pressure Vacuum Breaker

(Figure 38)

Field testing of a pressure vacuum breaker involves testing both the internal spring loaded soft seated check valve as well as testing the spring loaded air inlet valve. The testing must be performed with the device pressurized and the air inlet closed. The number 2 shut-off valve must also be closed and the air inlet valve canopy removed.

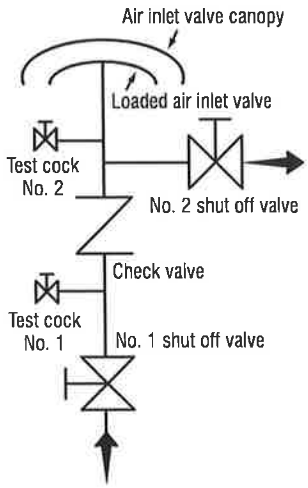
Method 1

Using a differential pressure gauge

Test 1 Test the internal check valve for tightness of 1 psid in the direction of flow.

1. With the valve body under pressure, (number 2 shut-off valve closed and number 1 shut-off valve open) bleed test cocks number 1 and number 2.
2. Hook up the high pressure hose to number 1 test cock and the low pressure hose to number 2 test cock.
3. Bleed the high pressure hose, and low pressure hose, in that order, and close the test kit needle valves slowly.
4. Record the differential pressure on the gauge. A reading of 1 psid is acceptable to insure a tight check valve.

FIGURE 38.



Test 2 Test the air inlet valve for a breakaway of 1 psi.

1. Connect the high pressure hose to test cock number 2, and bleed the high pressure hose.
2. Shut off number 1 shut-off valve.
3. Slowly open the bleed valve of the test kit, and observe and record the psi when the air inlet poppet opens. This should be a minimum of 1 psi. Restore the valve to normal service.

Method 2

Using a water column sight tube and 90 degree elbow fitting with bleed needle

Test 1 Test the internal check valve for tightness of 1 psid in the direction of flow.

1. Assemble sight tube to test cock number 1. Open test cock and fill the tube to a minimum of 36-inches of water height.
2. Close number 1 shut-off valve.
3. Open test cock number 2. The air inlet valve should open and discharge water through number 2 test cock.
4. Open number 1 test cock. The sight tube level of water should drop slowly until it stabilizes. This point should be a minimum of 28-inches of water column which equals 1 psi.

Test 2 Test the air inlet valve for a breakaway of 1 psi.

1. Assemble sight tube to test cock number 2. Open test cock number 2 and fill the tube to a minimum of 36-inches of water height.
2. Close number 1 shut-off valve.
3. Bleed water slowly from the number 2 test cock bleed needle and observe the water column height as it drops.
4. At the point when the air inlet valve pops open, record the height of the water column. This point should be a minimum of 28-inches of water column which equals 1psi.

Restore the valve to normal service.

Reduced Pressure Principle Backflow Preventer

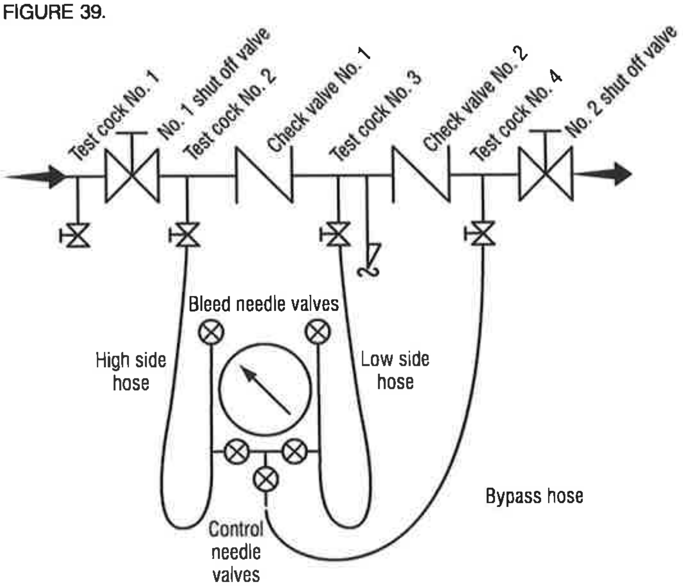
(Figure 39)

Field testing of a reduced pressure principle backflow preventer is accomplished utilizing a differential pressure gauge. The device is tested for three optional characteristics: i.e., (1) the first check valve is tight and maintains a minimum of 5 psi differential pressure, (2) the second check valve is tight against backpressure and (3) the relief valve opens at a minimum of 2 psi below inlet supply pressure. Testing is performed as follows:

Step 1 Test to insure that the first check valve is tight and maintains a minimum pressure of 5 psi differential pressure.

1. Verify that number 1 shut-off valve is open. Close number 2 shut-off valve. If there is no drainage from the relief valve it is assumed that the first check is tight.
2. Close all test kit valves.
3. Connect the high pressure hose to test cock number 2.
4. Connect the low pressure hose to test cock number 3.
5. Open test cocks number 2 and number 3.
6. Open high side bleed needle valve on test kit bleeding the air from the high hose. Close the high side bleed needle valve.
7. Open the low side bleed needle valve on test kit bleeding air from the low hose. Close the low side bleed needle valve. Record the differential gauge pressure. It should be a minimum of 5 psid.

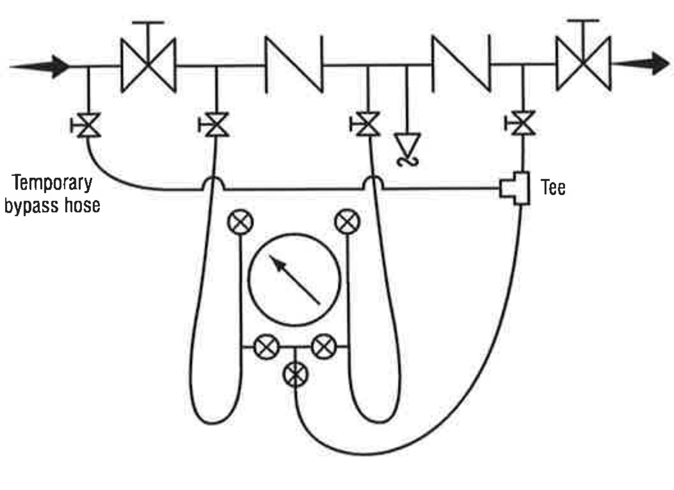
FIGURE 39.



Step 2 Test to insure that the second check is tight against backpressure. (Figure 40)

1. Leaving the hoses hooked up as in the conclusion of Step 1 above, connect the bypass hose to test cock number 4.
2. Open test cock number 4, the high control needle valve and the bypass hose control needle valve on the test kit. (This supplies high pressure water downstream of check valve number 2.) If the differential pressure gauge falls off and water comes out of the relief valve, the second check is recorded as leaking. If the differential pressure gauge remains steady, and no water comes out of the relief valve, the second check valve is considered tight

FIGURE 40.



3. To check the tightness of number 2 shut-off valve, leave the hoses hooked up the same as at the conclusion of Step 2 above, and then close test cock number 2. This stops the supply of any high pressure water downstream of check valve number 2. If the differential pressure gauge reading holds steady, the number 2 shut-off valve is recorded as being tight. If the differential pressure gauge drops to zero, the number 2 shut-off valve is recorded as leaking.

With a leaking number 2 shut-off valve, the device is, in most cases, in a flow condition and the previous readings taken are invalid. Unless a non-flow condition can be achieved, either through the operation of an additional shut-off downstream, or the use of a temporary compensating bypass hose, accurate test results will not be achieved.

Step 3 To check that the relief valve opens at a minimum pressure of 2 psi below inlet pressure.

1. With the hoses hooked up the same as at the conclusion of Step #2 (3) above, slowly open up the low control needle valve on the test kit and record the differential pressure gauge reading at the point when the water initially starts to drip from the relief valve opening. This pressure reading should not be below 2 psid.

This completes the standard field test for a reduced pressure principle backflow preventer. Before removal of the test equipment, the tester should insure that he opens number 2 shut-off valve thereby reestablishing flow. Also, the test kit should be thoroughly drained of all water to prevent freezing by opening all control needle valves and bleed needle valves.

All test data should be recorded on appropriate forms. (Ref: sample Page 45)

Note: The steps outlined above may vary in sequence depending upon local regulations and/or preferences.

Double Check Valve Assemblies

(Figure 41)
Some field test procedures for testing double check valve assemblies require that the number 1 shut-off valve be closed to accomplish the test. This procedure may introduce debris such as rust and tuberculin into the valve that will impact against check valve number 1 or number 2 and compromise the sealing quality. This potential problem should be considered prior to the selection of the appropriate test method.

Two test methods, one requiring closing of the number 1 shut-off valve, and one without this requirement are presented below:

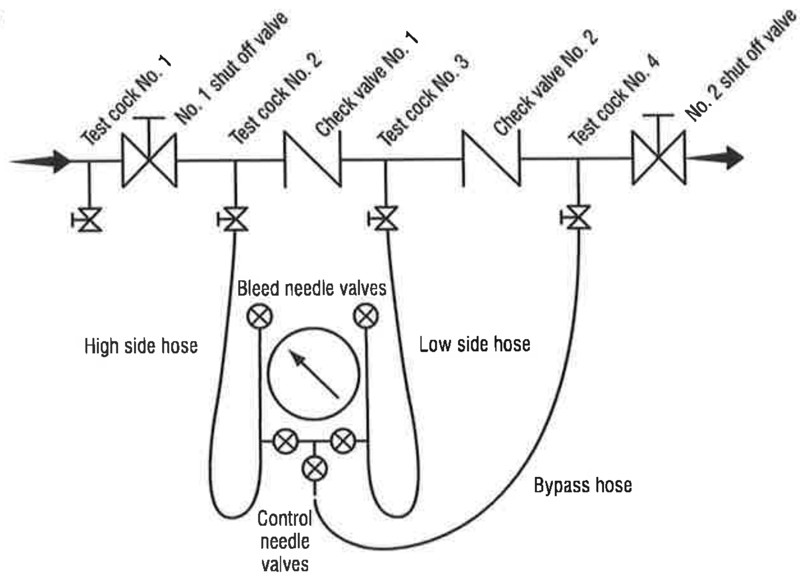
Method 1

Utilizing the differential pressure gauge and not shutting off number 1 shut-off valve. Figure 41)

Step 1 checking check valve number 1

1. Verify that the number 1 shut-off is open. Shut off number 2 shut-off valve.
2. Connect the high hose to test cock number 2.
3. Connect the low hose to test cock number 3.
4. Open test cocks 2 and 3.
5. Open high side bleed needle valve on test kit bleeding the air from the high hose. Close the high side bleed needle valve.
6. Open low side bleed needle valve on test kit bleeding the air from the low hose. Close the low side bleed needle valve.
7. Record the differential gauge pressure reading. It should be a minimum of 1 psid.
8. Disconnect the hoses.

FIGURE 41.



Step 2 Checking check valve number 2.

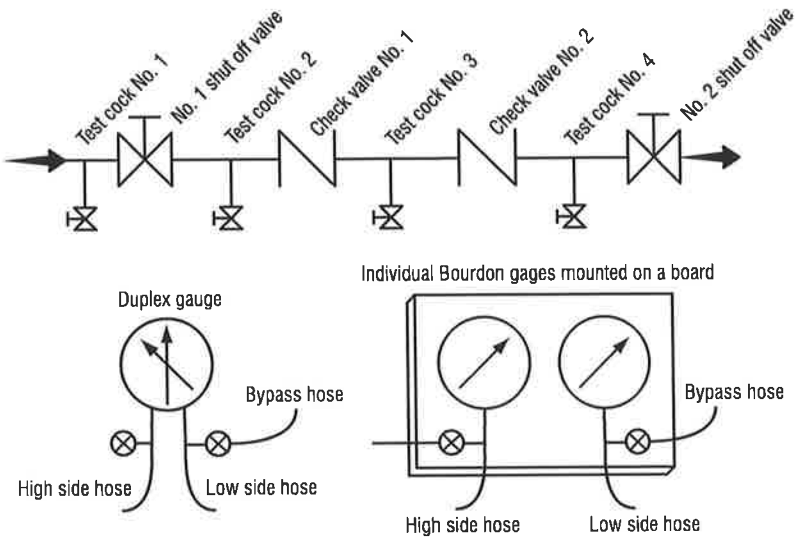
1. Connect the high hose to test cock number 3.
2. Connect the low hose to test cock number 4.
3. Open test cocks number 3 and 4.
4. Open high side bleed needle valve on test kit bleeding the air from the high hose. Close the high side bleed needle valve.
5. Open low side bleed needle valve on test kit bleeding the air from the low hose. Close the low side bleed needle valve.
6. Record the differential gauge pressure reading. It should be a minimum of 1 psid.
7. Disconnect the hoses.

To check tightness of number 2 shut-off valve, both the check valves must be tight and holding a minimum of 1 psid. Also, little or no fluctuation of inlet supply pressure can be tolerated.

The testing is performed as follows:

1. Connect the high hose to number 2 test cock.
2. Connect the low hose to number 3 test cock.
3. Connect the bypass hose to number 4 test cock.
4. Open test cocks numbers 2, 3, and 4.
5. Open high side bleed needle valve on test kit bleeding the air from the high hose. Close the high side bleed needle valve.
6. Open low side bleed needle valve on test kit bleeding the air from the low hose. Close the low side bleed needle valve.
7. The differential gauge pressure should read a minimum of 1 psid.
8. Open the high side control needle valve and the bypass hose control needle valve on the test kit. (This supplies high pressure water downstream of check valve number 2).
9. Close test cock number 2. (This stops the supply of any high pressure water downstream of number 2 check valve), If the differential pressure gauge holds steady, the number 2 shut-off valve is recorded as being tight. If the differential pressure gauge drops to zero, the number 2 shut-off valve is recorded as leaking.

FIGURE 42.



With a leaking number 2 shut-off valve, the device is, in most cases, in a flow condition, and the previous test readings taken are invalid. Unless a non-flow condition can be achieved, either through the operation of an additional shut-off down-stream, or the use of a temporary compensating bypass hose, accurate test results will not be achieved.

This completes the standard field test for a double check valve assembly. Prior to removal of the test equipment, the tester should insure that he opens number 2 shut-off valve thereby reestablishing flow. All test data should be recorded on appropriate forms and the test kit drained of water.

Method 2

Utilizing "Duplex Gauge" or individual bourdon gauges, requires closing number 1 shut-off. (Figure 42)

Step 1 checking check valve number 1

1. Connect the high hose to test cock number 2.
2. Connect the low hose to test cock number 3.
3. Open test cocks number 2 and number 3.
4. Close number 2 shut-off valve; then close number 1 shut-off valve.
5. By means of the high side needle valve, lower the pressure at test cock number 2 about 2 psi below the pressure at test cock number 3. If this small difference can be maintained, then check valve number 1 is reported as "tight". Proceed to Step number 2. If the small difference cannot be maintained, proceed to Step number 3.

Step 2 checking check valve number 2.

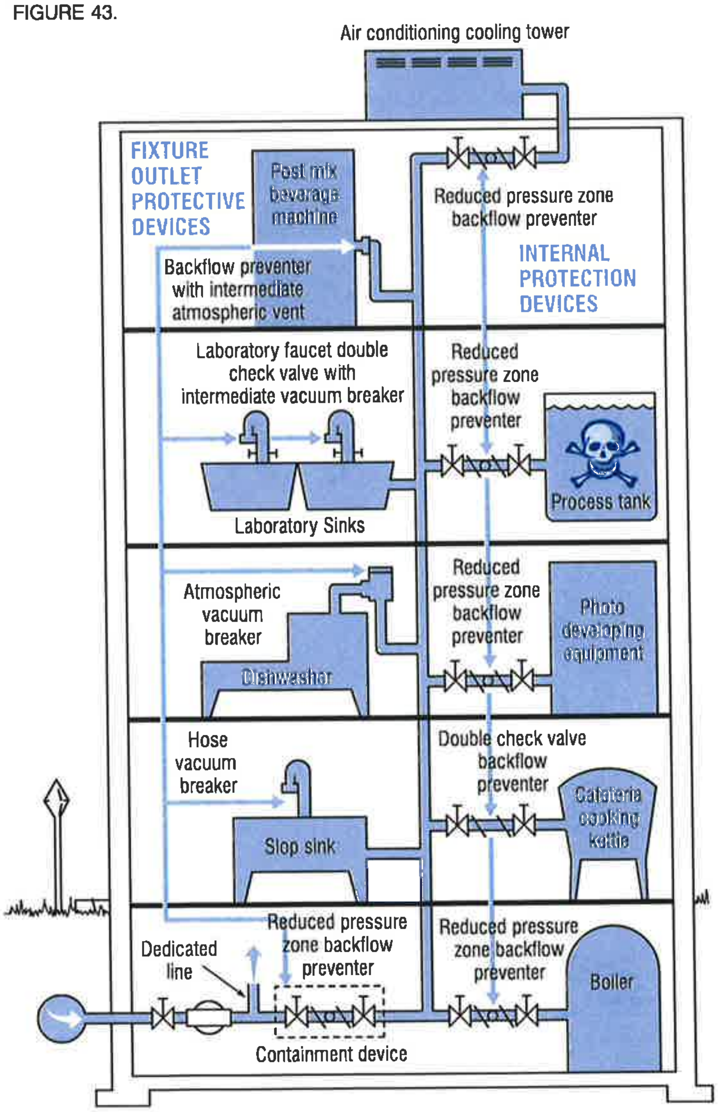
Proceed exactly the same test procedure as in Step number 1, except that the high hose is connected to test cock number 3 and the low hose connected to test cock number 4.

Step 3

1. Open shut-off valve number 1 to repressurize the assembly.
2. Loosely attach the bypass hose to test cock number 1, and bleed from the gauge through the bypass hose by opening the low side needle valve to eliminate trapped air. Close low side needle valve. Tighten bypass hose. Open test cock number 1.
3. Close number 1 shut-off valve.
4. By loosening the low side hose at test cock number 3, lower the pressure in the assembly about 10 psi below normal line conditions.
5. Simultaneously open both needle valves. If the check valve is holding tight the high pressure gauge will begin to drop while the low pressure gauge will increase. Close needle valves. If the gauge shows that a small (no more than 5 psi) backpressure is created and held, then the check valve is reported as tight. If the check valve leaks, a pressure differential is not maintained as both gauges tend to equalize or move back towards each other, then the check valve is reported as leaking. With both needle valves open enough to keep the needles on the gauge stationary, the amount of leakage is visible as the discharge from the upstream needle valve.

Administration of a Cross-Connection Control Program

FIGURE 43.



Responsibility

Under the provisions of the Safe Drinking Water Act of 1974, the Federal Government has established, through the EPA (Environmental Protection Agency), national standards of safe drinking water. The states are responsible for the enforcement of these standards as well as the supervision of public water supply systems and the sources of drinking water. The water purveyor (supplier) is held responsible for compliance to the provisions of the Safe Drinking Water Act, to include a warranty that water quality provided by his operation is in conformance with the EPA standards at the source, and is delivered to the customer without the quality being compromised as a result of its delivery through the distribution system. As specified in the Code of Federal Regulations (Volume 40, Paragraph 141.2, Section (c)) "Maximum contaminant level, means the maximum permissible level of a contaminant in water which is delivered to the free flowing outlet of the ultimate user of a public water system, except in the case of turbidity where the maximum permissible level is measured at the point of entry to the distribution system. Contaminants added to the water under circumstances controlled by the user, except those resulting from corrosion of piping and plumbing caused by water quality, are excluded from this definition."

Figure 43 depicts several options that are open to a water purveyor when considering cross-connection protection to commercial, industrial, and residential customers. He may elect to work initially on the "containment" theory. This approach utilizes a minimum of backflow devices and isolates the customer from the water main. It virtually insulates the customer from potentially contaminating or polluting the public water supply system. While it is recognized that "containment" does not protect the customer within his building, it does effectively remove him from possible contamination to the public water supply system. If the water purveyor elects to protect his customers on a domestic internal protective basis and/or "fixture outlet protective basis," then cross-connection control protective devices are placed at internal high hazard locations as well as at all locations where cross-connections exist at the "last free-flowing outlet." This approach entails extensive cross-connective survey work on behalf of the water superintendent as well as constant policing of the plumbing within each commercial, industrial and residential account. In large water supply systems, fixture outlet protection cross-connection control philosophy, in itself, is a virtual impossibility to achieve and police due to the quantity of systems involved, the complexity of the plumbing systems inherent in many industrial sites, and the fact that many plumbing changes are made within industrial and commercial establishments that do not require the water department to license or otherwise endorse or ratify when contemplated or completed.

In addition, internal plumbing cross-connection control survey work is generally foreign to the average water purveyor and is not normally a portion of his job description or duties. While it is admirable for the water purveyor to accept and perform survey work, he should be aware that he runs the risk of additional liability in an area that may be in conflict with plumbing inspectors, maintenance personnel and other public health officials.

Even where extensive "fixture outlet protection," cross-connection control programs are in effect through the efforts of an aggressive and thorough water supply cross-connection control program, the water authorities should also have an active "containment" program in order to address the many plumbing changes that are made and that are inherent within commercial and industrial establishments. In essence, fixture outlet protection becomes an extension beyond the "containment" program.

Also, in order for the supplier of water to provide maximum protection of the water distribution system, consideration should be given to requiring the owner of a premise (commercial, industrial, or residential) to provide at his own expense, adequate proof that his internal water system complies with the local or state plumbing code(s). In addition, he may be required to install, have tested, and maintain, all backflow protection devices that would be required—at his own expense!

The supplier of water should have the right of entry to determine degree of hazard and the existence of cross-connections in order to protect the potable water system. By so doing he can assess the overall nature of the facility and its potential impact on the water system (determine degree of hazard], personally see actual cross-connections that could contaminate the water system, and take appropriate action to insure the elimination of the cross-connection or the installation of required backflow devices.

To assist the water purveyor in the total administration of a cross-connection control program requires that all public health officials, plumbing inspectors, building managers, plumbing installers, and maintenance men participate and share in the responsibility to protect the public health and safety of individuals from cross-connections and contamination or pollution of the public water supply system.

Dedicated Line

Figure 43 also depicts the use of a "dedicated" potable water line. This line initiates immediately downstream of the water meter and is "dedicated" solely for human consumption i.e., drinking fountains, safety showers, eye wash stations, etc. It is very important that this piping be color coded throughout in accordance with local plumbing regulations, flow direction arrows added, and the piping religiously policed to insure that no cross-connections to other equipment or piping are made that could compromise water quality. In the event that it is felt that policing of this line cannot be reliably maintained or enforced, the installation of a containment device on this line should be a consideration.

A complete cross-connection control program requires a carefully planned and executed initial action plan followed by aggressive implementation and constant follow-up. Proper staffing and education of personnel is a requirement to insure that an effective program is achieved. A recommended plan of action for a cross-connection control program should include the following characteristics:

(1) Establish a cross-connection control ordinance at the local level and have it approved by the water commissioners, town manager, etc., and insure that it is adopted by the town or private water authority as a legally enforceable document.

(2) Conduct public informative meetings that define the proposed cross-connection control program, review the local cross-connection control ordinance, and answer all questions that may arise concerning the reason for the program, why and how the survey will be conducted, and the potential impact upon the industrial, commercial and residential water customers. Have state authorities and the local press and radio attend the meeting.

(3) Place written notices of the pending cross-connection control program in the local newspaper, and have the local radio station make announcements about the program as a public service notice.

(4) Send employees who will administer the program, to a course, or courses, on backflow tester certification, backflow survey courses, backflow device repair courses, etc.

(5) Equip the water authority with backflow device test kits.

(6) Conduct meeting(s) with the local plumbing inspection people, building inspectors, and licensed plumbers in the area who will be active in the inspection, installations and repair of backflow devices. Inform them of the intent of the program and the part that they can play in the successful implementation of the program.

(7) Prior to initiating a survey of the established commercial and industrial installations, prepare a list of these establishments from existing records, then prioritize the degree of hazard that they present to the water system, i.e., plating plants, hospitals, car wash facilities, industrial metal finishing and fabrication, mortuaries, etc. These will be the initial facilities inspected for cross-connections and will be followed by less hazardous installations.

(8) Insure that any new construction plans are reviewed by the water authority to assess the degree of hazard and insure that the proper backflow preventer is installed concurrent with the potential degree of hazard that the facility presents.

(9) Establish a residential backflow protection program that will automatically insure that a residential dual check backflow device is installed automatically at every new residence.

(10) As water meters are repaired or replaced at residences, insure that a residential dual check backflow preventer is set with the new or reworked water meter. Be sure to have the owner address thermal expansion provisions.

(11) Prepare a listing of all testable backflow devices in the community and insure that they are tested by certified test personnel at the time intervals consistent with the local cross-connection control ordinance.

(12) Prepare and submit testing documentation of backflow devices to the State authority responsible for monitoring this data.

(13) Survey all commercial and industrial facilities and require appropriate backflow protection based upon the containment philosophy and/or internal protection and fixture outlet protection. Follow up to insure that the recommended devices are installed and tested on both an initial basis and a periodic basis consistent with the cross-connection control ordinance.

The surveys should be conducted by personnel experienced in commercial and industrial processes. The owners or owners representatives, should be questioned as to what the water is being used for in the facility and what hazards the operations may present to the water system (both within the facility and to the water distribution system) in the event that a backsiphonage or backpressure condition were to exist concurrent with a non-protected cross-connection. In the event that experienced survey personnel are not available within the water authority to conduct the survey, consideration should be given to having a consulting firm perform the survey on behalf of the water department.

Cross-Connection Control Survey Work

Cross-connection control survey work should only be performed by personnel knowledgeable about commercial and industrial potential cross-connections as well as general industrial uses for both potable and process water. If "containment" is the prime objective of the survey, then only sufficient time need be spent in the facility to determine the degree of hazard inherent within the facility or operation. Once this is determined, a judgment can be made by the cross-connection control inspector as to what type of backflow protective device will be needed at the potable supply entrance, or immediately downstream of the water meter. In the event that the cross-connection control program requires "total" protection to the last free flowing outlet, then the survey must be conducted in depth to visually inspect for all cross-connections within the facility and make recommendations and requirements for fixture outlet protective devices, internal protective devices, and containment devices.

It is recommended that consideration be given to the following objectives when performing a cross-connection control survey:

(1) Determine if the survey will be conducted with a pre-arranged appointment or unannounced.

(2) Upon entry, identify yourself and the purpose of the visitation and request to see the plant manager, owner, or maintenance supervisor in order to explain the purpose of the visit and why the cross-connection survey will be of benefit to him.

(3) Ask what processes are involved within the facility and for what purpose potable water is used, i.e., do the boilers have chemical additives? Are air conditioning cooling towers in use with chemical additives? Do they use water savers with chemical additives? Do they have a second source of water (raw water from wells, etc.) in addition to the potable water supply? Does the process water cross-connect with potentially hazardous chemical etching tanks, etc.?

(4) Request "as-built" engineering drawings of the potable water supply in order to trace out internal potable lines and potential areas of cross-connections.

(5) Initiate the survey by starting at the potable entrance supply (the water meter in most cases) and then proceed with the internal survey in the event that total internal protective devices and fixture outlet protective devices are desired.

(6) Survey the plant facilities with the objective of looking for cross-connections at all potable water outlets such as:

- Hose bibbs
- Slop sinks
- Wash room facilities
- Cafeteria and kitchens
- Fire protection and Siamese outlets
- Irrigation outlets
- Boiler rooms
- Mechanical room
- Laundry facilities (hospitals)
- Production floor

(7) Make a sketch of all areas requiring backflow protection devices.

(8) Review with the host what you have found and explain the findings to him. Inform him that he will receive a written report documenting the findings together with a written recommendation for corrective action. Attempt to answer all questions at this time. Review the findings with the owner or manager if time and circumstances permit.

(9) Document all findings and recommendations prior to preparing the written report. Include as many sketches or photos with the final report as possible. If the located cross connection(s) cannot be eliminated, state the generic type of backflow preventer required at each cross connection found.

(10) Consider requiring or recommending compliance of the survey findings within a definitive time frame. (if appropriate authority is in effect).

Cross-Connection Control and Backflow Prevention Program

The successful promotion of a cross-connection control and backflow prevention program in a municipality will be dependent upon legal authority to conduct such a program. Where a community has adopted a modern plumbing code, such as the National Plumbing Code, ASA A40.8-1955, or subsequent revisions thereof, provisions of the code will govern backflow and cross-connections. It then remains to provide an ordinance that will establish a program of inspection for an elimination of cross- and backflow connections within the community. Frequently authority for such a program may already be possessed by the water department or water authority. In such cases no further document may be needed. A cross-connection control ordinance should have at least three basic parts.

1. Authority for establishment of a program.
2. Technical provisions relating to eliminating backflow and cross-connections.
3. Penalty provisions for violations.

The following model program is suggested for municipalities who desire to adopt a cross-connection control ordinance. Communities adopting ordinances should check with State health officials to assure conformance with State codes. The form of the ordinance should comply with local legal requirements and receive legal adoption from the community.

CROSS CONNECTION CONTROL
MODEL PROGRAM

WATER DEPARTMENT NAME
ADDRESS

DATE

Approved ________________

Date ____________________

Water Department Name Cross-Connection Control Program

I. Purpose

A. To protect the public potable water supply served by the ( ) Water Department from the possibility of contamination or pollution by isolating, within its customers internal distribution system, such contaminants or pollutants which could backflow or back-siphon into the public water system.

B. To promote the elimination or control of existing cross-connections, actual or potential, between its customers in-plant potable water system, and non-potable systems.

C. To provide for the maintenance of a continuing program of cross-connection control which will effectively prevent the contamination or pollution of all potable water systems by cross-connection.

II. Authority

A. The Federal Safe Drinking Water Act of 1974, and the statutes of the State of ( ) Chapters ( ) the water purveyor has the primary responsibility for preventing water from unapproved sources, or any other substances, from entering the public potable water system.

B. ( ) Water Department, Rules and Regulations, adopted.

III. Responsibility

The Director of Municipal Services shall be responsible for the protection of the public potable water distribution system from contamination or pollution due to the backflow or backsiphonage of contaminants or pollutants through the water service connection. If, in the judgment of the Director of Municipal Services, an approved backflow device is required at the city's water service connection to any customer's promises, the Director, or his delegated agent, shall give notice in writing to said customer to install an approved backflow prevention device at each service connection to his premises. The customer shall, within 90 days install such approved device, or devices, at his own expense, and failure or refusal, or inability on the part of the customer to install said device or devices within ninety (90) days, shall constitute a ground for discontinuing water service to the premises until such device or devices have been properly installed.

IV. Definitions

A. Approved

Accepted by the Director of Municipal Services as meeting an applicable specification stated or cited in this regulation, or as suitable for the proposed use.

B. Auxiliary Water Supply

Any water supply, on or available, to the premises other than the purveyor's approved public potable water supply.

C. Backflow

The flow of water or other liquids, mixtures or substances, under positive or reduced pressure in the distribution pipes of a potable water supply from any source other than its intended source.

D. Backflow Preventer

A device or means designed to prevent backflow or backsiphonage. Most commonly categorized as air gap, reduced pressure principle device, double check valve assembly, pressure vacuum breaker, atmospheric vacuum breaker, hose bibb vacuum breaker, residential dual check, double check with intermediate atmospheric vent, and barometric loop.

D.1 Air Gap

A physical separation sufficient to prevent backflow between the free-flowing discharge end of the potable water system and any other system. Physically defined as a distance equal to twice the diameter of the supply side pipe diameter but never less than one (1) inch.

D.2 Atmospheric Vacuum Breaker

A device which prevents backsiphonage by creating an atmospheric vent when there is either a negative pressure or subatmospheric pressure in a water system.

D.3 Barometric Loop

A fabricated piping arrangement rising at least thirty five (35) feet at its topmost point above the highest fixture it supplies. It is utilized in water supply systems to protect against backsiphonage.

D.4 Double Check Valve Assembly

An assembly of two (2) independently operating spring loaded check valves with tightly closing shut off valves on each side of the check valves, plus properly located test cocks for the testing of each check valve.

D.5 Double Check Valve with Intermediate Atmospheric Vent

A device having two (2) spring loaded check valves separated by an atmospheric vent chamber.

D.6 Hose Bibb Vacuum Breaker

A device which is permanently attached to a hose bibb and which acts as an atmospheric vacuum breaker.

D.7 Pressure Vacuum Breaker

A device containing one or two independently operated spring loaded check valves and an independently operated spring loaded air inlet valve located on the discharge side of the check or checks. Device includes tightly closing shut-off valves on each side of the check valves and properly located test cocks for the testing of the check valve(s).

D.8 Reduced Pressure Principle Backflow Preventer

An assembly consisting of two (2) independently operating approved check valves with an automatically operating differential relief valve located between the two (2) check valves, tightly closing shut-off valves on each side of the check valves plus properly located test cocks for the testing of the check valves and the relief valve.

D.9 Residential Dual Check

An assembly of two (2) spring loaded, independently operating check valves without tightly closing shut-off valves and test cocks. Generally employed immediately downstream of the water meter to act as a containment device.

E. Backpressure

A condition in which the owners system pressure is greater than the suppliers system pressure.

F. Backsiphonage

The flow of water or other liquids, mixtures or substances into the distribution pipes of a potable water supply system from any source other than its intended source caused by the sudden reduction of pressure in the potable water supply system.

G. Commission

The State of (   ) Control Commission.

H. Containment

A method of backflow prevention which requires a backflow prevention preventer at the water service entrance.

I. Contaminant

A substance that will impair the quality of the water to a degree that it creates a serious health hazard to the public leading to poisoning or the spread of disease.

J. Cross-Connection

Any actual or potential connection between the public water supply and a source of contamination or pollution.

K. Department

City of ( ) Water Department.

L. Fixture Isolation

A method of backflow prevention in which a backflow preventer is located to correct a cross connection at an in-plant location rather than at a water service entrance.

M. Owner

Any person who has legal title to, or license to operate or habitat in, a property upon which a cross-connection inspection is to be made or upon which a cross-connection is present.

N. Person

Any individual, partnership, company, public or private corporation, political subdivision or agency of the State Department, agency or instrumentality or the United States or any other legal entity.

O. Permit

A document issued by the Department which allows the use of a backflow preventer.

P. Pollutant

A foreign substance, that if permitted to get into the public water system, will degrade its quality so as to constitute a moderate hazard, or impair the usefulness or quality of the water to a degree which does not create an actual hazard to the public health but which does adversely and unreasonably effect such water for domestic use.

Q. Water Service Entrance

That point in the owners water system beyond the sanitary control of the District; generally considered to be the outlet end of the water meter and always before any unprotected branch.

R. Director of Municipal Services

The Director, or his delegated representative in charge of the ( ) Department of Municipal Services, is invested with the authority and responsibility for the implementation of a cross-connection control program and for the enforcement of the provisions of the Ordinance.

V. Administration

A. The Department will operate a cross-connection control program, to include the keeping of necessary records, which fulfills the requirements of the Commission's Cross-Connection Regulations and is approved by the Commission.

B. The Owner shall allow his property to be inspected for possible cross-connections and shall follow the provisions of the Department's program and the Commission's Regulations if a cross-connection is permitted.

C. If the Department requires that the public supply be protected by containment, the Owner shall be responsible for water quality beyond the outlet end of the containment device and should utilize fixture outlet protection for that purpose.

He may utilize public health officials, or personnel from the Department, or their delegated representatives, to assist him in the survey of his facilities and to assist him in the selection of proper fixture outlet devices, and the proper installation of these devices.

VI. Requirements

A. Department

1. On new installations, the Department will provide on-site evaluation and/or inspection of plans in order to determine the type of backflow preventer, if any, that will be required, will issue permit, and perform inspection and testing. In any case, a minimum of a dual check valve will be required in any new construction.

2. For premises existing prior to the start of this program, the Department will perform evaluations and inspections of plans and/or premises and inform the owner by letter of any corrective action deemed necessary, the method of achieving the correction, and the time allowed for the correction to be made. Ordinarily, ninety (90) days will be allowed, however, this time period may be shortened depending upon the degree of hazard involved and the history of the device(s) in question.

3. The Department will not allow any cross-connection to remain unless it is protected by an approved backflow preventer for which a permit has been issued and which will be regularly tested to insure satisfactory operation.

4. The Department shall inform the Owner by letter, of any failure to comply, by the time of the first re-inspection. The Department will allow an additional fifteen (15) days for the correction. In the event the Owner fails to comply with the necessary correction by the time of the second re-inspection, the Department will inform the Owner by letter, that the water service to the Owner's premises will be terminated within a period not to exceed five (5) days. In the event that the Owner informs the Department of extenuating circumstances as to why the correction has not been made, a time extension may be granted by the Department but in no case will exceed an additional thirty (30) days.

5. If the Department determines at any time that a serious threat to the public health exists, the water service will be terminated immediately.

6. The Department shall have on file, a list of Private Contractors who are certified backflow device testers. All charges for these tests will be paid by the Owner of the building or property.

7. The Department will begin initial premise inspections to determine the nature of existing or potential hazards, following the approval of this program by the Commission, during the calendar year (   ). Initial focus will be on high hazard industries and commercial premises.

B. Owner

1. The Owner shall be responsible for the elimination or protection of all cross-connections on his premises.

2. The Owner, after having been informed by a letter from the Department, shall at his expense, install, maintain, and test, or have tested, any and all backflow preventers on his premises.

3. The Owner shall correct any malfunction of the backflow preventer which is revealed by periodic testing.

4. The Owner shall inform the Department of any proposed or modified cross-connections and also any existing cross-connections of which the Owner is aware but has not been found by the Department.

5. The Owner shall not install a bypass around any backflow preventer unless there is a backflow preventer of the same type on the bypass. Owners who cannot shut down operation for testing of the device(s) must supply additional devices necessary to allow testing to take place. (Ref. Fig. 33 page 23.)

6. The Owner shall install backflow preventers in a manner approved by the Department. (Ref. Figures 3 through 37, pages 23 through 24.)

7. The Owner shall install only backflow preventers approved by the Department or the Commission.

8. Any Owner having a private well or other private water source, must have a permit if the well or source is cross-connected to the Department's system. Permission to cross-connect may be denied by the Department. The Owner may be required to install a backflow preventer at the service entrance if a private water source is maintained, even if it is not cross-connected to the Department's system.

9. In the event the Owner installs plumbing to provide potable water for domestic purposes which is on the Department's side of the backflow preventer, such plumbing must have its own backflow preventer installed.

10. The Owner shall be responsible for the payment of all fees for permits, annual or semi-annual device testing, retesting in the case that the device fails to operate correctly, and second re-inspections for non-compliance with Department or Commission requirements.

VII. Degree of Hazard

The Department recognizes the threat to the public water system arising from cross-connections. All threats will be classified by degree of hazard and will require the installation of approved reduced pressure principle backflow prevention devices or double check valves.

VIII. Permits

The Department shall not permit a cross-connection within the public water supply system unless it is considered necessary and that it cannot be eliminated.

A. Cross-connection permits that are required for each backflow prevention device are obtained from the Department. A fee of (   ) dollars will be charged for the initial permit and (   ) dollars for the renewal of each permit.

B. Permits shall be renewed every (   ) years and are non-transferable. Permits are subject to revocation and become immediately revoked if the Owner should so change the type of cross-connection or degree of hazard associated with the service.

C. A permit is not required when fixture isolation is achieved with the utilization of a non-testable backflow preventer.

IX. Existing in-use backflow prevention devices.

Any existing backflow preventer shall be allowed by the Department to continue in service unless the degree of hazard is such as to supercede the effectiveness of the present backflow preventer, or result in an unreasonable risk to the public health. Where the degree of hazard has increased, as in the case of a residential installation converting to a business establishment, any existing backflow preventer must be upgraded to a reduced pressure principle device, or a reduced pressure principle device must be installed in the event that no backflow device was present.

X. Periodic Testing

A. Reduced pressure principle backflow devices shall be tested and inspected at least semi-annually.

B. Periodic testing shall be performed by the Department's certified tester or his delegated representative. This testing will be done at the owner's expense.

C. The testing shall be conducted during the Department's regular business hours. Exceptions to this, when at the request of the owner, may require additional charges to cover the increased costs to the Department.

D. Any backflow preventer which fails during a periodic test will be repaired or replaced. When repairs are necessary, upon completion of the repair the device will be re-tested at owners expense to insure correct operation. High hazard situations will not be allowed to continue unprotected if the backflow preventer fails the test and cannot be repaired immediately. In other situations, a compliance date of not more than thirty (30) days after the test date will be established. The owner is responsible for spare parts, repair tools, or a replacement device. Parallel installation of two (2) devices is an effective means of the owner insuring that uninterrupted water service during testing or repair of devices and is strongly recommended when the owner desires such continuity. (Ref. Fig. 33 page 23.)

E. Backflow prevention devices will be tested more frequently than specified in A. above, in cases where there is a history of test failures and the Department feels that due to the degree of hazard involved, additional testing is warranted. Cost of the additional tests will be born by the owner.

XI. Records and Reports

A. Records

The Department will initiate and maintain the following:

1. Master files on customer cross-connection tests and/or inspections.
2. Master files on cross-connection permits.
3. Copies of permits and permit applications.
4. Copies of lists and summaries supplied to the Commission.

B. Reports

The Department will submit the following to the Commission.

1. Initial listing of low hazard cross-connections to the State.
2. Initial listing of high hazard cross-connections to the State.
3. Annual update lists of items 1 and 2 above.
4. Annual summary of cross-connection inspections to the State.

XII. Fees and Charges

The Department will publish a list of fees or charges for the following services or permits:

1. Testing fees
2. Re-testing fees
3. Fee for re-inspection
4. Charges for after-hours inspections or tests.

Addendum

1. Residential dual check

Effective the date of the acceptance of this Cross-Connection Control Program for the Town of (   ) all new residential buildings will be required to install a residential dual check device immediately downstream of the water meter. (Ref. Figure 37 page 24.) Installation of this residential dual check device on a retrofit basis on existing service lines will be instituted at a time and at a potential cost to the homeowner as deemed necessary by the Department.

The owner must be aware that installation of a residential dual check valve results in a potential closed plumbing system within his residence. As such, provisions may have to be made by the owner to provide for thermal expansion within his closed loop system, i.e., the installation of thermal expansion devices and/or pressure relief valves.

2. Strainers

The Department strongly recommends that all new retrofit installations of reduced pressure principle devices and double check valve backflow preventers include the installation of strainers located immediately upstream of the backflow device. The installation of strainers will preclude the fouling of backflow devices due to both foreseen and unforeseen circumstances occurring to the water supply system such as water main repairs, water main breaks, fires, periodic cleaning and flushing of mains, etc. These occurrences may "stir up" debris within the water main that will cause fouling of backflow devices installed without the benefit of strainers.

Appendix A

Partial List of Plumbing Hazards

Fixtures with Direct Connections

Description

Air conditioning, air washer
Air conditioning, chilled water
Air conditioning, condenser water
Air line
Aspirator, laboratory
Aspirator, medical
Aspirator, weedicide and fertilizer sprayer
Autoclave and sterilizer
Auxiliary system, industrial
Auxiliary system, surface water
Auxiliary system, unapproved well supply
Boiler system
Chemical feeder, pot-type
Chlorinator
Coffee urn
Cooling system
Dishwasher
Fire standpipe or sprinkler system
Fountain, ornamental
Hydraulic equipment
Laboratory equipment
Lubrication, pump bearings
Photostat equipment
Plumber's friend, pneumatic
Pump, pneumatic ejector
Pump, prime line
Pump, water operated ejector
Sewer, sanitary
Sewer, storm
Swimming pool

Fixtures with Submerged Inlets

Description

Baptismal fount
Bathtub
Bedpan washer, flushing rim
Bidet
Brine tank
Cooling tower
Cuspidor
Drinking fountain
Floor drain, flushing rim
Garbage can washer
Ice maker
Laboratory sink, serrated nozzle
Laundry machine
Lavatory
Lawn sprinkler system
Photo laboratory sink
Sewer flushing manhole
Slop sink, flushing rim
Slop sink, threaded supply
Steam table
Urinal, siphon jet blowout
Vegetable peeler
Water closet, flush tank, ball cock
Water closet, flush valve, siphon jet

Appendix B

Illustrations of Backsiphonage

The following illustrates typical plumbing installations where backsiphonage is possible.

Backsiphonage

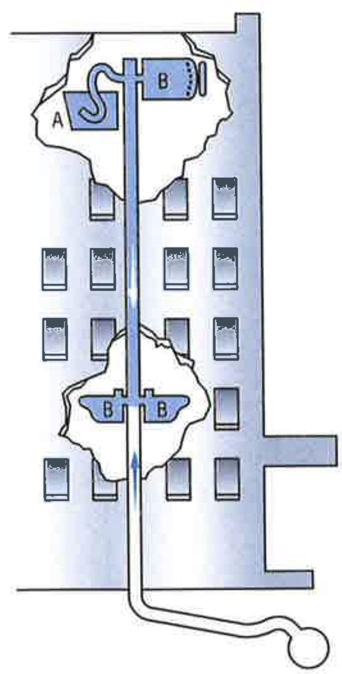
Case I (Fig. 44)

A. Contact Point: A rubber hose is submerged in a bedpan wash sink.

B. Causes of Reversed Flow: (I) A sterilizer connected to the water supply is allowed to cool without opening the air vent. As it cools, the pressure within the sealed sterilizer drops below atmospheric producing a vacuum which draws the polluted water into the sterilizer contaminating its contents. (2) The flushing of several flush valve toilets on a lower floor which are connected to an undersized water service line reduces the pressure at the water closets to atmospheric producing a reversal of the flow.

C. Suggested Correction: The water connection at the bedpan wash sink and the sterilizer should be provided with properly installed backflow preventers.

FIGURE 44.
Backsiphonage (Case 1).



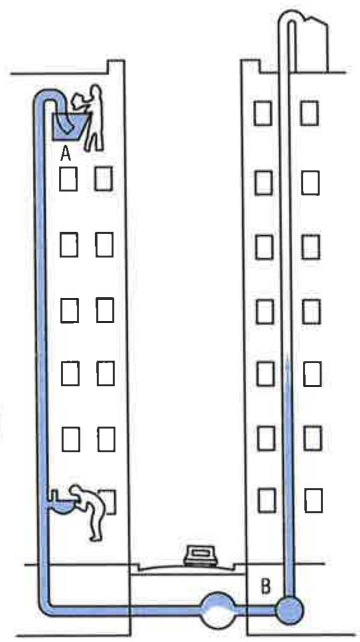
Backsiphonage

Case 2 (Fig. 45)

A. Contact Point: A rubber hose is submerged in a laboratory sink.

B. Cause of Reversed Flow: Two opposite multi-story buildings are connected to the same water main, which often lacks adequate pressure. The building on the right has installed a booster pump.

FIGURE 45.
Backsiphonage (Case 2).



When the pressure is inadequate in the main, the building booster pump starts pumping, producing a negative pressure in the main and causing a reversal of flow in the opposite building.

C. Suggested Correction: The laboratory sink water outlet should be provided with a vacuum breaker. The water service line to the booster pump should be equipped with a device to cut off the pump when pressure approaches a negative head or vacuum.

Backsiphonage

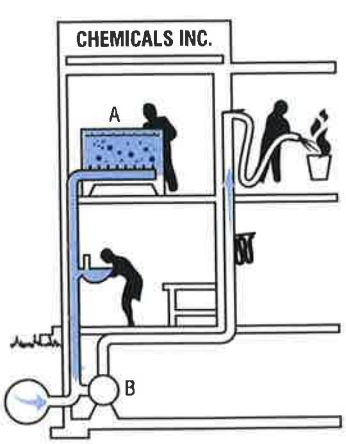
Case 3 (Fig. 46)

A. Contact Point: A chemical tank has a submerged inlet.

B. Cause of Reversed Flow: The plant fire pump draws suction directly from the city water supply line which is insufficient to serve normal plant requirements and a major fire at the same time. During a fire emergency, reversed flow may occur within the plant.

C. Suggested Correction: The water service to the chemical tank should be provided through an air gap.

FIGURE 46.
Backsiphonage (Case 3).



Backsiphonage

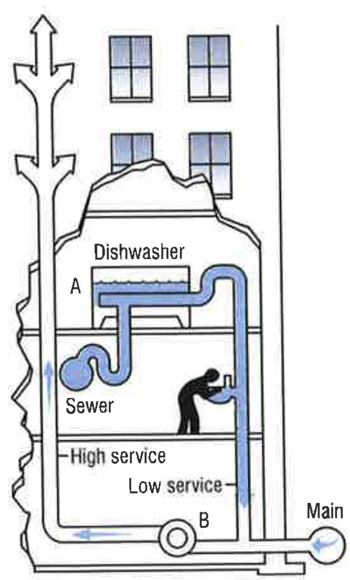
Case 4 (Fig. 47)

A. Contact Point: The water supply to the dishwasher is not protected by a vacuum breaker. Also, the dishwasher has a solid waste connection to the sewer.

B. Cause of Reversed Flow: The undersized main serving the building is subject to reduced pressures, and therefore only the first two floors of the building are supplied directly with city pressure. The upper floors are served from a booster pump drawing suction directly from the water service line. During periods of low city pressure, the booster pump suction creates negative pressures in the low system, thereby reversing the flow.

C. Suggested Correction: The dishwasher hot and cold water should be supplied through an air gap and the waste from the dishwasher should discharge through an indirect waste. The booster pump should be equipped with a low-pressure cutoff device.

FIGURE 47.
Backsiphonage (Case 4).



Backsiphonage

Case 5 (Fig. 48)

A. Contact Point: The gasoline storage tank is maintained full and under pressure by means of a direct connection to the city water distribution system.

FIGURE 48.
Backsiphonage (Case 5).

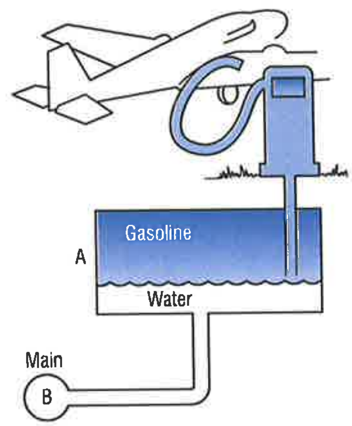
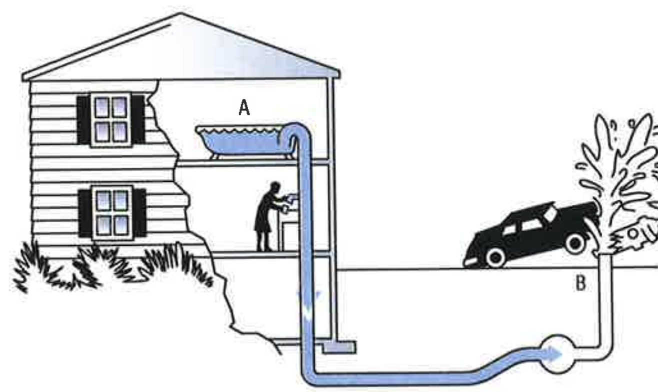


FIGURE 49.
Backsiphonage (Case 6).



B. Cause of Reversed Flow: Gasoline may enter the distribution system by gravity or by siphonage in the event of a leak or break in the water main.

C. Suggested Correction: A reduced pressure principle backflow preventer should be installed in the line to the gasoline storage tank or a surge tank and pump should be provided in that line.

Backsiphonage

Case 6 (Fig. 49)

A. Contact Point: There is a submerged inlet in the second floor bathtub.

B. Cause of Reversed Flow: An automobile breaks a nearby fire hydrant causing a rush of water and a negative pressure in the service line to the house, sucking dirty water out of the bathtub.

C. Suggested Correction: The hot and cold water inlets to the bathtub should be above the rim of the tub.

Illustrations of Backpressure

The following presents illustrations of typical plumbing installations where backflow resulting from backpressure is possible.

Backflow

Case I (Fig. 50)

A. Contact Point: A direct connection from the city supply to the boiler exists as a safety measure and for filling the system. The boiler water system is chemically treated for scale prevention and corrosion control.

B. Cause of Reversed Flow: The boiler water recirculation pump discharge pressure or backpressure from the boiler exceeds the city water pressure and the chemically treated water is pumped into the domestic system through an open or leaky valve.

C. Suggested Correction: As minimum protection two check valves in series should be provided in the makeup waterline to the boiler system. An air gap separation or reduced pressure principle backflow preventer is better.

FIGURE 50.
Backflow (Case 1).

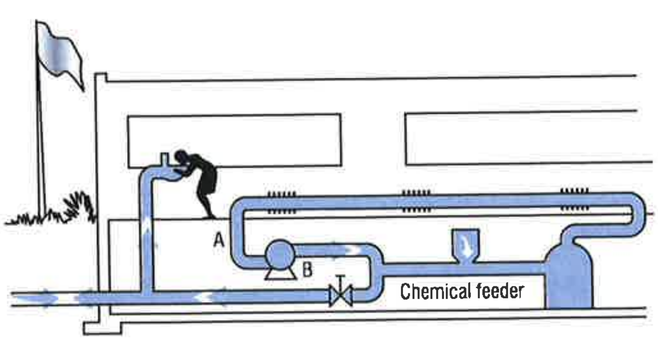
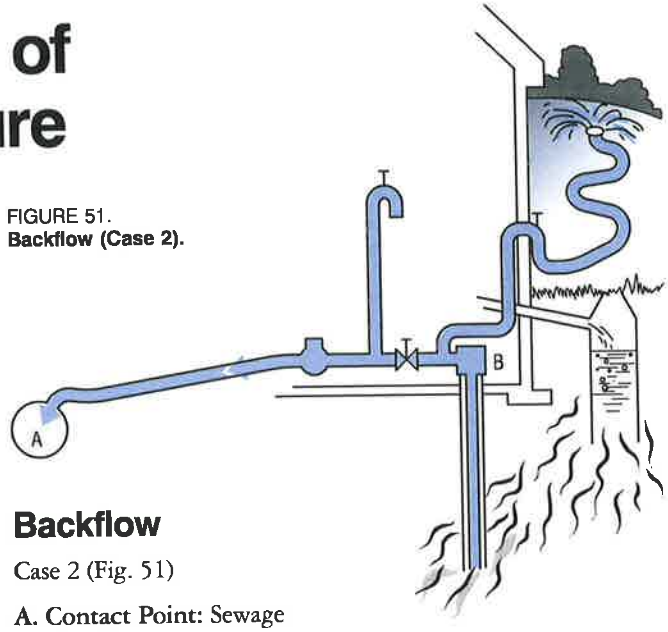


FIGURE 51.
Backflow (Case 2).



Backflow

Case 2 (Fig. 51)

A. Contact Point: Sewage seeping from a residential cesspool pollutes the private well which is used for lawn sprinkling. The domestic water system, which is served from a city main, is connected to the well supply by means of a valve. The purpose of the connection may be to prime the well supply for emergency domestic use.

B. Cause of Reversed Flow: During periods of low city water pressure, possibly when lawn sprinkling is at its peak, the well pump discharge pressure exceeds that of the city main and well water is pumped into the city supply through an open or leaky valve.

C. Suggested Correction: The connection between the well water and city water should be broken

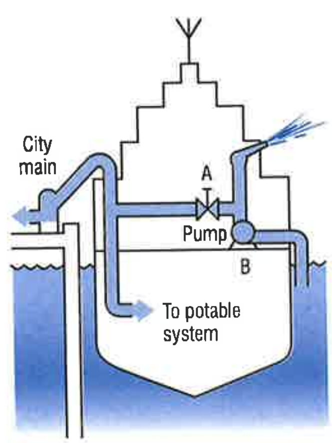
Backflow

Case 3 (Fig. 52)

A. Contact Point: A valve connection exists between the potable and the non potable systems aboard the ship.

B. Cause of Reversed Flow: While the ship is connected to the city water supply system for the purpose of taking on water for the potable system, the valve between the potable and nonpotable systems is opened, permitting contaminated water to be pumped into the municipal supply.

FIGURE 52.
Backflow (Case 3).



C. Suggested Correction: Each pier water outlet should be protected against backflow. The main water service to the pier should also be protected against backflow by an air gap or reduced pressure principle backflow preventer.

Backflow

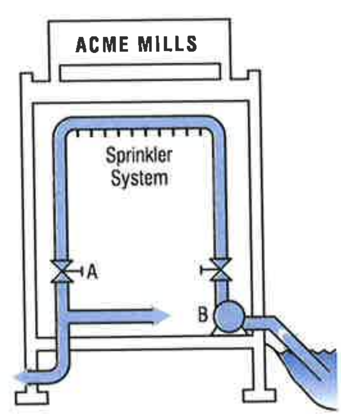
Case 4 (Fig. 53)

A. Contact Point: A single-valved connection exists between the public, potable water supply and the fire-sprinkler system of a mill.

B. Cause of Reversed Flow: The sprinkler system is normally supplied from a nearby lake through a high-pressure pump. About the lake are large numbers of overflowing septic tanks. When the valve is left open, contaminated lake water can be pumped to the public supply.

C. Suggested Correction: The potable water supply to the fire system should be through an air gap or a reduced pressure principle backflow preventer should be used.

FIGURE 53.
Backflow (Case 4).



Illustrations of Air Gaps

The following illustrations describe methods of providing an air gap discharge to a waste line which may be occasionally or continuously subject to backpressure.

FIGURE 54.
Air gap to sewer subject to backpressure—force main.

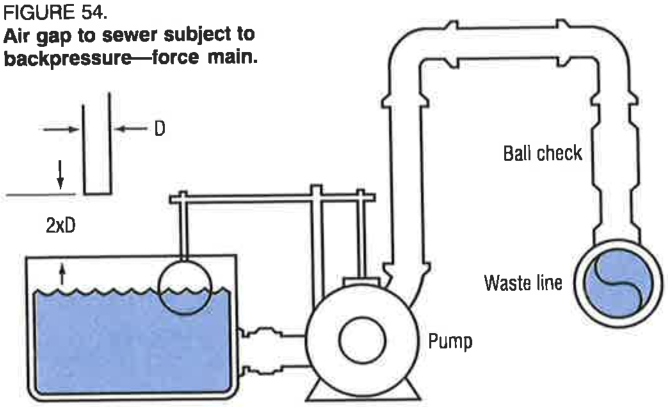


FIGURE 55.
Air gap to sewer subject to backpressure—gravity drain.

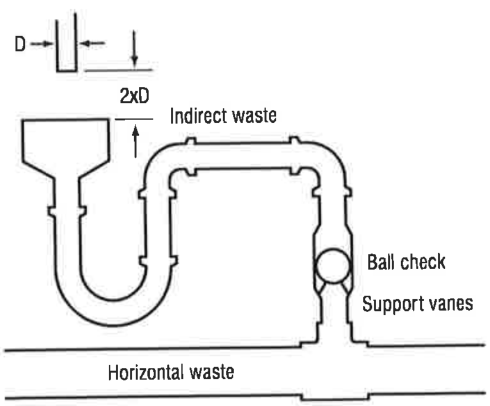
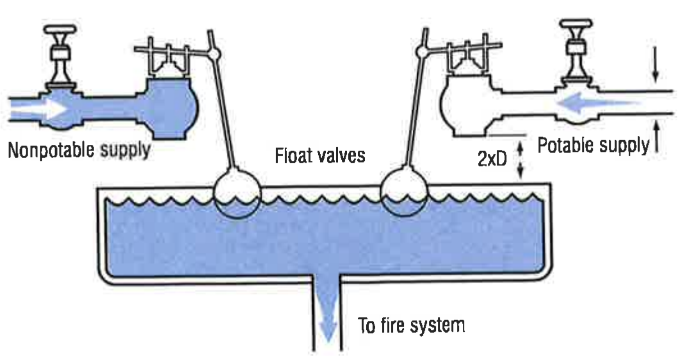


FIGURE 56.
Fire system makeup tank for a dual water system.



Illustrations of Vacuum Breakers

FIGURE 57.
Vacuum breakers.

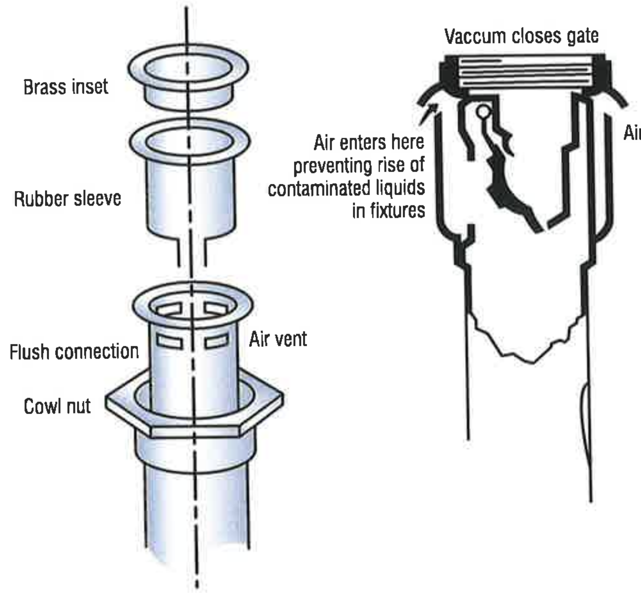
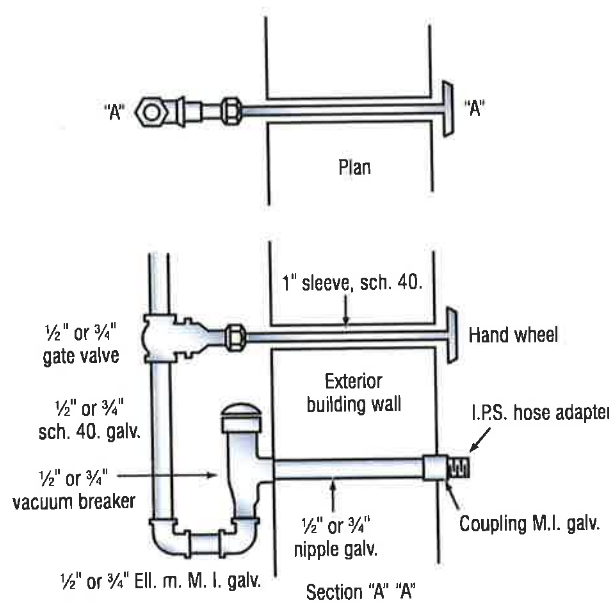


FIGURE 58.
Vacuum breaker arrangement for an outside hose hydrant.



(By permission of Mr. Gustave J. Angele Sr., P.E. formerly Plant Sanitary Engineer, Union Carbide Nuclear Division, Oak Ridge, Tenn.)

Glossary

Air gap The unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying water to a tank, plumbing fixture, or other device and the flood-level rim of the receptacle.

Backflow The flow of water or other liquids, mixtures, or substances into the distributing pipes of a potable supply of water from any source or sources other than its intended source. Backsiphonage is one type of backflow.

Backflow Connection Any arrangement whereby backflow can occur.

Backflow Preventer A device or means to prevent backflow. Backflow Preventer, Reduced Pressure Principle Type An assembly of differential valves and check valves including an automatically opened spillage port to the atmosphere.

Backsiphonage Backflow resulting from negative pressures in the distributing pipes of a potable water supply.

Cross-Connection Any actual or potential connection between the public water supply and a source of contamination or pollution.

Effective Opening The minimum cross-sectional area at the point of water supply discharge, measured or expressed in terms of (1) diameter of a circle, or (2) if the opening is not circular, the diameter of a circle or equivalent cross-sectional area.

Flood-Level Rim The edge of the receptacle from which water overflows.

Flushometer Valve A device which discharges a predetermined quantity of water to fixtures for flushing purposes and is actuated by direct water pressure.

Free Water Surface A water surface that is at atmospheric pressure.

Frostproof Closet A hopper with no water in the bowl and with the trap and water supply control valve located below frost line.

Indirect Waste Pipe A drain pipe used to convey liquid wastes that does not connect directly with the drainage system, but which discharges into the drainage system through an air break into a vented trap or a properly vented and trapped fixture, receptacle, or interceptor.

Plumbing The practice, materials, and fixtures used in the installation, maintenance, extension, and alteration of all piping, fixtures, appliances and appurtenances in connection with any of the following: sanitary drainage or storm drainage facilities, the venting system and the public or private water-supply systems, within or adjacent to any building, structure, or conveyance; also the practice and materials used in the installation, maintenance, extension, or alteration of storm water, liquid waste, or sewerage, and water-supply systems of any premises to their connection with any point of public disposal or other acceptable terminal.

Potable Water Water free from impurities present in amounts sufficient to cause disease or harmful physiological effects. Its bacteriological and chemical quality shall conform to the requirements of the USEPA National Primary Drinking Water Regulations and the regulations of the public health authority having jurisdiction.

Vacuum Any absolute pressure less than that exerted by the atmosphere.

Vacuum Breaker A device that permits air into a water supply distribution line to prevent backsiphonage.

Water Outlet A discharge opening through which water is supplied to a fixture, into the atmosphere (except into an open tank which is part of the water supply system), to a boiler or heating system, to any devices or equipment requiring water to operate but which are not part of the plumbing system.

Water Supply System The water service pipe, the water-distributing pipes, and the necessary connecting pipes, fittings, control valves, and all appurtenances in or adjacent to the building or premises. The water supply system is part of the plumbing system.

Appendix G

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Cross-Connection Survey Form

Date: ______________________________

Name of Company, Corporation, or Business: ______________________________

____

Address: ______________________________

Name of Contact: ______________________________

Type of Use: Industrial ________ Commercial ________ Governmental ________ Other

Location of Service: ______________________________

Size of Service: ____________________ Inch Metered? Yes ☐ No ☐

Require non-interrupted water service? Yes ☐ No ☐

Does Boiler Feed utilize chemical additives? Yes ☐ No ☐

Is Backflow protection incorporated? Yes ☐ No ☐

Are air conditioning cooling towers utilized? Yes ☐ No ☐

Is Backflow protection incorporated? Yes ☐ No ☐

Is a Water Saver utilized on condensing lines or cooling towers? N/A ☐ Yes ☐ No ☐

Is the make-up supply line backflow protected? Yes ☐ No ☐

Is process water in use, and if so, is it potable supply water or "Raw" water N/A ☐ Potable ☐

Raw ☐ Protected ☐ Unprotected ☐

Is fire protection water separate from the potable supply? Yes ☐ No ☐

Are Containment Devices in place? Yes ☐ No ☐

Summary

Degree of Hazard: High ☐ Low ☐

Type of Device recommended for containment: RPZ ☐ DCV ☐ None ☐

Fixture Outlet protection required? Yes ☐ No ☐

If so, where?

____

Backflow Prevention Device Test and Maintenance Report

To: ____
(water purveyor or regulatory agency)

____

____

Attn: Cross-connection Control Section

The cross-connection control device detailed hereon has been tested and maintained as required by the *(rules or regulations)* of *(purveyor or regulatory agency)* and is certified to comply with these *(rules or regulations)*.

Make of device ______________ size ______________________

Model Number ______________ located at ______________________

Serial Number ______________ ______________________

____

	Reduced Pressure Devices			Pressure Vacuum Breaker	
	Double Check Devices		Relief Valve	Air Inlet	Check Valve
	1st Check	2nd Check			
Initial Test	DC - Closed Tight ☐ RP - ______ psid Leaked ☐	Closed Tight ☐ Leaked ☐	Opened at ______ psid	Opened at ______ psid Did not open ☐	______ psid Leaked ☐
Repairs and Materials Used					
Test After Repair	DC-Closed Tight RP- ______ psid	Closed Tight ☐	Opened at ______ psid	Opened at ______ psid	______ psid

The above is certified to be true.

Firm Name ______________________ Certified Tester ______________________

Firm Address ______________________ Cert. Tester No. ______________ Date ________

____

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EPA 816-R-03-002
www.epa.gov/safewater
February 2003

Potential Contamination Due to Cross-Connections and Backflow and the Associated Health Risks

An Issues Paper

by

EPA's Office of Ground Water and
Drinking Water

1.0 Nature and Purpose of the Paper

This paper is one of nine papers that examine issues related to drinking water distribution systems. The nine papers are products of two expert workshops. The first workshop, in June 2000, discussed issues associated with distribution systems that may pose public health risks and identified those issues of most concern. The distribution system issues of most concern identified at the workshop are the following: Microbial Growth and Biofilms; Cross-Connections and Backflow; Intrusion; Corrosion and Aging Infrastructure; Decay of Water Quality over Distribution System Residence Time; Contamination During Infrastructure Repair and Replacement; Nitrification; Covered Storage; and Permeation and Leaching. The second workshop, in March 2002, discussed the first drafts prepared on those issues.

In support of the nine distribution system issue papers, EPA developed two tables that list many of the biological and chemical contaminants represented in the papers and their potential health effects: the Microbial Contaminant Health Effects Table (for acute and chronic health effects) and the Chemical Contaminant Health Effects Table (for chronic health effects). For those contaminants mentioned in this paper and included in these tables, a reference to the tables is provided for further information on potential health effects.

The purpose of this document is to review existing literature, research, and information on the occurrence, magnitude, and nature of the public health risks associated with cross-connections and backflow, from both acute and chronic exposures, and methods for detecting and controlling the occurrence of cross-connections and backflow within distribution systems. More specifically, the goal of this document is to review what we know regarding: (1) causes of contamination through cross-connections; (2) the magnitude of risk associated with cross-connections and backflow; (3) costs of backflow contamination incidents; (4) other problems associated with backflow incidents; (5) suitable measures for preventing and correcting problems caused by cross-connections and backflow; (6) possible indicators of a backflow incident; and (7) research opportunities.

2.0 Executive Summary

Within distribution systems there exist points called cross-connections where nonpotable water can be connected to potable sources. These cross-connections can provide a pathway for backflow of nonpotable water into potable sources. Backflow can occur either because of reduced pressure in the distribution system (termed backsiphonage) or the presence of increased pressure from a nonpotable source (termed backpressure). Backsiphonage may be caused by a variety of circumstances, such as main breaks, flushing, pump failure, or emergency firefighting water drawdown. Backpressure may occur when heating/cooling, waste disposal, or industrial manufacturing systems are connected to potable supplies and the pressure in the external system exceeds the pressure in the distribution system. Both situations act to change the direction of water, which normally flows from the distribution system to the customer, so that nonpotable and potentially contaminated water from industrial, commercial, or residential sites flows back into the distribution system through a cross-connection. During incidents of backflow, these chemical and biological contaminants have caused illness and deaths, with contamination affecting a number of service connections. The number of incidents actually reported is believed to be a small percentage of the total number of backflow incidents in the United States.

The risk posed by backflow can be mitigated through preventive and corrective measures. For example, preventative measures include the installation of backflow prevention devices and assemblies and formal programs to seek out and correct cross-connections within the distribution system and, in some cases, within individual service connections. Corrective measures include activities such as flushing and cleaning the distribution system after a detected incident. These may help mitigate any further adverse health effects from any contaminants that may remain in the distribution system.

3.0 Definition of Key Terms

A cross-connection is a point in a plumbing system where it is possible for a nonpotable substance to come into contact with the potable drinking water supply (BMI, 1999). According to the University of Southern California's Foundation for Cross-Connection Control and Hydraulic Research (USC FCCCHR) (1993), a cross-connection means,

> "any unprotected actual or potential connection or structural arrangement between a public or private potable water system, and any other source or system through which it is possible to introduce into any part of the potable system any used water, industrial fluids, gas, or substance other than the intended potable water with which the potable system is supplied."

Common examples of cross-connections include a garden hose submerged in a pesticide mixture, a piped connection providing potable feed water to an industrial process, such as a cooling tower, or a submerged outlet of an irrigation system. Connections to firefighting equipment are other very common cross-connections. Most cross-connections occur beyond the customer service connection, within residential, commercial, institutional or industrial plumbing systems. Identifying cross-connections can be challenging because many distribution systems are expanding to serve new customers and changing to accommodate customer needs. Further, temporary and permanent cross-connections can be created in existing facilities without the knowledge of the water system managers and operators.

Backflow is any unwanted flow of used or nonpotable water, or other substances from any domestic, industrial, or institutional piping system back into the potable water distribution system[1] (USC FCCCHR, 1993). The direction of flow under these conditions is opposite to that of normal flow. The reverse pressure gradient that leads to backflow is caused by either backsiphonage or backpressure (USC FCCCHR, 1993; BMI, 1996).

Backsiphonage is backflow caused by negative or sub-atmospheric pressure in a portion of the distribution system or the supply piping (USC FCCCHR, 1993). When the system pressure drops to below atmospheric (negative gauge pressure), ambient pressure on the distribution system due to the atmosphere, water columns (from buildings or other elevated piping), or other sources will cause the direction of flow within portions of the system to reverse. If a cross-connection exists in the area where flow reverses direction, contaminants can be siphoned into the distribution system (USC FCCCHR, 1993). Water main breaks, firefighting efforts, high demands, and any situation where water is withdrawn from the distribution system at a high rate can lead to backsiphonage (USC FCCCHR, 1993).

Backpressure can cause backflow to occur when a potable system is connected to a nonpotable supply operating under a higher pressure than the distribution system by means of a pump, boiler, elevation difference, air or steam pressure, or other means (USC FCCCHR, 1993). Unlike

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[1]This paper defines the distribution system to be from the point at which the water leaves the treatment plant, or source, if untreated, to the point at which the customer's service line begins.

backsiphonage, it is not necessary to have a drop in distribution system pressure for backpressure to occur. Whenever the pressure at the point of a cross-connection exceeds the pressure of the distribution system, the direction of flow will reverse. There is a high risk that nonpotable water will be forced into the potable system whenever these connections are not properly protected (USC FCCCHR, 1993).

4.0 What Causes Contamination Through Cross-Connections to Occur?

This section of the paper describes how cross-connections and backflow occur, and what conditions and situations are necessary to cause them. Under intended flow conditions, distribution systems are pressurized to deliver finished water from the treatment plant to the customer. However, two situations can cause the direction of flow to reverse: pressure in the distribution system can drop due to various conditions or an external system connected to the distribution system may operate at a higher pressure than the distribution system. These differences in pressure can cause contaminants to be drawn or forced into the distribution system. Contamination introduced due to backflow into the distribution system may then flow freely into other customer connections. The following conditions must be present for contamination to occur through cross-connections.

- A cross-connection exists between the potable water distribution system and a nonpotable source.

- The pressure in the distribution system either becomes negative (backsiphonage), or the pressure of a contaminated source exceeds the pressure inside the system (backpressure).

- The cross-connection is not protected, or the connection is protected and the mechanism failed, allowing the backflow incident.

The extent of contamination in the distribution system depends, in part, on the location of the cross-connection, the concentration of the contaminant entering the distribution system and the magnitude and duration of the pressure difference causing the backflow. This section of the paper describes the theory of backflow and cross-connections, provides examples of conditions that can create backflow, and lists a number of factors that affect the likelihood and magnitude of backflow through a cross-connection.

4.1 Backflow Conditions

The occurrence of backflow is directly related to system pressure. Any pressure differential between the potable water and the non-potable source can lead to backflow. It is estimated that even well-run water distribution systems experience about 25–30 breaks per 100 miles of piping per year (Deb et al., 1995). Haas (1999) reported results from a survey of water systems that showed a range of average main breaks of 488 per year for systems serving more than 500,000 people, to 1.33 per year for systems serving fewer than 500 people.

Fighting fires also reduces a system's pressure (AWWA, 1999). For example, in 1974 in Washington State, the high rate of flow caused by the activation of a fire deluge system reduced pressure in a domestic water line, causing backsiphonage of a chemical and other pollutants into the potable water system (AWWA PNWS, 1995). Similarly, opening hydrants during the summer for recreational use causes pressure to drop. Regular system maintenance activities such as valve exercising programs, hydrant flushing, pump repair, pressure control valve repair, and valve replacement can also result in localized variations in pressure that cause backflow. Differences in elevation can compound the effects of pressure loss.

Additionally, if a high pressure source is connected to the distribution system, a drop in pressure is not necessary for backflow to occur—the presence of a cross-connection or failure of the prevention mechanism will allow backflow to occur.

Examples of backsiphonage

Elevated piping can cause backsiphonage when there is a loss of pressure in the supply system. The loss of pressure will cause the water column to collapse and create a vacuum that can draw contaminants in through a cross-connection (BMI, 1999; USC FCCCHR, 1993). Backsiphonage can also occur within irrigation systems. For example, in 1991, a water main break lead to the backsiphonage of parasitic worms from a residential lawn sprinkler supply into two homes (AWWA PNWS, 1995).

Booster pumps for high-rise buildings can cause backsiphonage if the suction lines of the pumps are being used for service on the lower floors and a temporary or permanent cross-connection on the lower floors exists (e.g., a hose submerged in a bucket of cleaning solution). If distribution system pressure drops, the suction pressure can cause the backsiphonage through the lower floor cross-connection when the pump is operating, contaminating the higher floors (BMI, 1999; USC FCCCHR, 1993; US EPA, 1989).

Localized physical restrictions in water lines can produce backsiphonage through the venturi effect (BMI, 1999). When water flows through a restriction—for example, through a garden hose or from a larger water line into a smaller one—its velocity increases and its pressure decreases proportionately (US EPA, 1989). This decrease in pressure can yield negative pressure and siphon substances into the point of restriction (BMI, 1999). Devices such as chemical sprayers used on the end of garden hoses use this principle to siphon chemical from the container into the water stream (BMI, 1996).

Backsiphonage can occur when supply piping within an industrial facility is elevated over the rim of a vessel, and the outlet of that piping is submerged in a liquid contaminant. Negative distribution system pressure would cause the water column in the elevated pipe section to collapse, creating a vacuum that draws contaminants from the vessel into the distribution system (BMI, 1999; USC FCCCHR, 1993).

If a pipe with cracks or leaking joints is exposed to a wet environment, negative pressure can cause water to be drawn in (or to intrude into) the distribution system through backsiphonage (Kirmeyer et al., 2001). A separate issue paper addresses risks from intrusion due to pressure transients.

Examples of backpressure

Backpressure can occur with pressurized residential, industrial, institutional, or commercial systems which use pumps, including chemical feed pumps or booster pumps, or pressurized auxiliary water systems for irrigation, fire protection, car washes, and cooling systems (USC FCCCHR, 1993; FDEP, 2001). For example, backpressure resulting from tank cleaning activities by a gas company in Connecticut caused propane to backflow into the distribution system, causing fires in two homes and evacuation of hundreds of people. Gas company workers were purging a propane tank with water and did not realize the pressure in the tank was greater than in the water line feeding the tank, thus creating a backpressure of propane vapor into the distribution system (US EPA, 1989). Backpressure also occurred in 1991 at a facility that transforms wheat and barley into ethanol in Tucumcari, New Mexico. An unprotected auxiliary water line feeding emergency fire cannons was illegally tapped to a hose connected to an ethanol plant's flushing system, creating a cross-connection. After the plant finished its flushing operation, the plant resumed normal operations with the hose still connected, and backpressure from plant operations forced a number of industrial chemicals to backflow into the public water supply (toluene, phenol, benzene, ethanol, nonanoic acid, decanoic acid, octanol, octanoic acid, heptanoic acid, butanoic acid, silicon, diconic acid and four trihalomethanes). The concentrations of these toxins were enough to cause the mayor of the town to become very ill for 48 hours. Another individual drank a small amount of water and became ill with stomach upset. Fortunately, there were no deaths, and the distribution system was thoroughly flushed after the contamination was detected (AWWA PNWS, 1995). The likelihood of backpressure increases when the distribution system pressure drops to below normal operating pressure due to changes in valve setting, pipeline breaks, air valve slams, loose-fitting service meter connections, surge or feed tank draining, or a sudden change in demand (Kirmeyer et al., 2001).

The weight of water in piping of high-rise buildings is a source of backpressure on the distribution system. Backpressure can also come from thermal expansion (high pressures can be generated when water is heated in a closed container). Thermal expansion can occur in boilers, solar heating systems, and places where water- or foam-based fire sprinkler systems are located on the highest floors of tall buildings and temperatures of piping rise (BMI, 1999).

Compressed air systems such as carbonators can pose backpressure risks. The pressure of a carbon dioxide tank, for example, can be several thousand pounds per square inch (psi). This high-pressure carbon dioxide is passed through a regulator and mixed into a water system at anywhere from 60 to 150 psi. Carbon dioxide from either a tank or a regulator could be introduced to the distribution system pressure if a cross-connection is present and the compressed air system overcomes the distribution system pressure (Guy, 1997).

4.2 Factors Affecting the Occurrence and Magnitude of Backflow Contamination

Operating pressure

A minimum operating pressure of 20 psi at all locations in a distribution system is suggested by various manuals and codes of good operating practice (Kirmeyer et al., 2001). Some states also have minimum operating pressure requirements. Local operating pressure in a system varies among zones. In a highly pressurized system, a great deal of backpressure would be needed to force water to backflow; a system or part of a system with relatively low pressure would generally be more susceptible to backpressure. Systems with normal operating pressure lower than recommended by manuals and codes of good practice may have a higher risk of backpressure events.

Reduced pressures that can lead to backflow occur from a variety of sources. Water main breaks, hilly terrain, limited pumping capacity, high demand by consumers, fire fighting flows, rapidly opening or closing a valve within the distribution system, power loss, and hydrant flushing can reduce pressure and contribute to lower or extremely fluctuating water pressures (Kirmeyer et al., 2001). A study of a distribution system (LeChevallier et al., 2001) observed that during a pump test, routine operation, and a power outage, pressures as low was -10.1 psi were recorded, with durations ranging from 16 to 51 seconds. During these times of negative pressure, the chance that water external to the distribution system intruded into the distribution system due to backsiphonage or backpressure increased. In a simple single pipe model employed in the study, a surge generated by a simulated power failure to a pump predicted 69 gallons of external water would intrude into the pipe within 60 seconds. A surge caused by a main break predicted 78 gallons of water intruding within 60 seconds. A survey of 70 systems reported 11,186 pressure reduction incidents in the past year; 34.8 percent of the incidents were from routine flushing, 19.2 percent were due to main breaks, and 16.2 percent incidents were due to service line breaks (ABPA, 2000). Hills and other elevations compound pressure loss effects caused by main breaks, fire flows, and other events (ABPA, 2000). Limited pumping capacity may cause periodic termination of water supply in areas of the system. Without sufficient redundancy in the distribution system, backsiphonage conditions may occur if one or more major components of the distribution system go offline or otherwise cease functioning.

Physical security of the distribution system

Homeland security initiatives include attention to the physical security of water distribution systems. The subject of homeland security is well beyond the scope of this paper, but it is relevant to note that the potential for intentional contamination of a distribution system through cross-connections and backflow of chemical and biological contaminants is possible (Dreazen, 2001).

Maintenance activities

Maintenance levels and practices within the distribution system can affect the likelihood of occurrence of cross-connections and backflow. In a South Carolina system in 1978 fifteen people became ill due to backsiphonage of chlordane from an exterminator truck during meter repair (USC FCCCHR, 1993). In May, 1982 maintenance crews in Bancroft, Michigan shut down a main to replace a valve. The resultant pressure loss caused backflow of malathion from a hose end applicator , and resulted in the loss of water to the village for two days (USC FCCCHR, 1993). The herbicide Lexon DF backsiphoned into the distribution system in Gridley, Kansas in 1987 from a tanker truck when a main broke during excavation and contaminated ten residences and one business (USC FCCCHR, 1993).

Levels of public awareness

A lack of public awareness about the threat posed by cross-connections and backflow can lead to unintentional creation of cross-connections, such as through illegal and unprotected taps into the distribution system. In 1979, a professional exterminator left a garden hose submerged in a barrel of diluted pesticide, allowing chlordane to be backsiphoned into the distribution system during a service interruption (US EPA, 1989). This potential is magnified in multi-storied buildings that have many people living under one primary connection. Cross-connections are often installed by the public as a matter of convenience without regard to possible dangers, and others with reliance on inadequate backflow prevention (US EPA, 1989).

5.0 The Magnitude of Risk Associated with Cross-Connections and Backflow

This section describes the risk posed by contaminants that can enter the distribution system through cross-connections. The history of outbreaks and reported illnesses associated with cross-connections and backflow indicates some level of public health risk is associated with cross-connections and backflow. Risk is a function of a variety of factors including cross-connection and backflow occurrence, type and amount of contaminants, and their potential health effects. This section first describes the reported outbreaks of disease associated with cross-connections and backflow, then follows with a description of some contaminants that have been introduced to distribution systems via cross-connections and backflow, and the difficulties in detecting and reporting backflow incidents.

5.1 Reported Outbreaks Associated with Cross-Connections and Backflow

From 1981 to 1998, CDC documented 57 waterborne disease outbreaks related to cross-connections, resulting in 9,734 illnesses. These include 20 outbreaks (6,333 cases of illness) caused by microbiological contamination, 15 outbreaks (679 cases of illness) caused by chemical contamination, and 22 outbreaks (2,722 cases of illness) where the contaminant was not reported. Craun and Calderon (2001) report that 30.3 percent of waterborne disease outbreaks in community water systems during 1971-1998 were caused by contamination of water in the distribution systems. Of these waterborne disease outbreaks caused by distribution system deficiencies, 50.6 percent were due to cross-connection and backflow (Craun and Calderon, 2001). Documented acute health impacts most often involve gastrointestinal disorders. The data from the CDC's surveillance of the outbreak of waterborne disease must meet certain documentation standards; therefore, these reports are reliable. However, CDC's reporting standards exclude some incidents that lack complete documentation and report only outbreaks of notifiable diseases (a set of diseases that CDC tracks; these do not include endemic diseases). As a result, these data are likely under-estimates and these under-estimates are compounded by the number of illnesses that go unreported. (Section 5.4 further discusses the difficulties of detecting and reporting waterborne disease outbreaks.)

Estimates of the proportion of waterborne illness attributable to cross-connections and backflow vary. A compilation by EPA's Health Effects Research Laboratory found that between 1920 and 1980, cross-connections and backflow caused 78 percent of outbreaks, and 95 percent of the cases of illness, attributed to community distribution system contamination in the United States (AWWA, 1990).

Data on health impacts are also available from other sources that collect information on backflow incidents, such as USC FCCCHR, and the Cross-Connection Control Committee of the Pacific Northwest Section of the AWWA. These independent organizations do not limit their data to well-defined outbreaks, but focus on incidents. Because not all incident reports document illness, estimates of illness resulting from an individual incident based on their data are less reliable than CDC estimates of reported outbreaks.

Our compilation of backflow incident data (summarized in Exhibit 5.1) found that 459 incidents resulted in an estimated 12,093[2] illnesses from 1970 to 2001. When we narrowed the analysis to 1981-1999, for comparison with CDC data on outbreaks for that period, we found that only 97 of 309 incidents produced reports of how many (if any) illnesses were caused, and 22 of these 97 incidents reported no illnesses. Of the remaining 75 incidents, only 26 appear in CDC's summaries as a waterborne disease outbreak. This suggests that CDC data underreport even known instances of illness caused by backflow contamination. From the 75 incidents that produced reports of illness, analysis of the qualitative and quantitative case reports estimated 4,416 illnesses, averaging 46 illnesses per outbreak.

5.2 Contaminants Associated with Cross-Connections and Backflow and Their Health Effects

A variety of contaminants have been introduced into distribution systems by cross-connections and backflow, indicated by the backflow occurrence discussed in this paper. The likelihood and severity of illness and number of people affected depend on various factors including how much contamination

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[2]If the number of illnesses was reported qualitatively, the analysis used the following assumptions to estimate a total figure. Specifically, if the number of illnesses was reported as "several", "many", or "numerous", the analysis assumed five. The analysis assumed that "some" meant three. One incident reported "dozens" of illnesses this analysis assumed 36. Another reported one family the analysis assumed three people.

enters the system, the dilution factor, the type of contaminant, the number of users exposed, and the health status of each person at the time of exposure.

Contamination from cross-connections and backflow can occur not only where the cross-connection is located but at sites upstream and downstream, as contaminants spread. The fate and transport of a contaminant are often system-specific and can be difficult to predict because they depend on multiple parameters such as the hydraulics of the distribution system and the physical, chemical, or biological properties of the contaminant. The contaminant may remain as a slug, resulting in very high concentrations in localized areas, or it may disperse, contaminating large volumes of water at lower concentrations. It may adsorb to the interior of pipes, necessitating their cleaning or replacement. It may degrade, or in the case of microorganisms, be inactivated or injured by residual disinfectant. It may also become concentrated within the biofilms and be slowly released through erosion or as a slug through biofilm sloughing. Scales within the piping may adsorb the contaminants for later release.

The Chemical and Microbial Health Effects Tables, developed by EPA to support the nine issue papers, include many biological and chemical contaminants mentioned in the papers. However, additional contaminants not listed in these tables are described in this paper because the types of contaminants that have entered distribution systems through cross-connections are numerous and not discussed in any other white papers; thus more appropriately described in this paper. For those contaminants listed in the Health Effects Tables, this paper references the appropriate table for more information on potential health effects.

5.2.1 Chemical Contaminants

The use of chemicals at residential, industrial, and commercial facilities with direct or indirect connections to potable water systems presents an opportunity for contamination from cross-connections and backflow (USC FCCCHR, 1993). Many of these chemicals have some degree of toxicity, and exposure to these chemicals can have either acute or long-term health effects, depending on the nature and concentration of the contaminant, duration of exposure, and a person's immune status. Exposure from contamination through a cross-connection can be either acute or chronic. While waterborne outbreaks are under-reported in general, rarely are waterborne chemical outbreaks reported to CDC. The reasons for under-reporting of chemical outbreaks above and beyond that of microbial outbreaks include: 1) most poisonings of this nature (e.g., lead and copper from plumbing) probably occur in private residences, affect relatively few people and, thus, may not come to the attention of public health officials; 2) exposure to chemicals via drinking water may cause illness that is difficult to attribute to chemical intoxication, or it may cause non-specific symptoms that are difficult to link to a specific agent; and 3) the chemical outbreak detection mechanisms, as well as the reporting requirements are not as well established as they are for microbial agents (CDC, 1996). Most reported incidents are acute exposures, however, chronic exposures are possible if immediate water quality or health effects are not noticed, or if cross-connections remain uncorrected long-term. This can result in some of the chronic health effects described in the Chemical Health Effects Table (US EPA, 2002a), when the consumer is exposed to the chemicals listed for a long period of time. Depending on the contaminant, these chronic exposures can cause long-term health effects, including cancer, which may not be identified until many years after the initial exposure. Acute health risks include vomiting, bums, poisoning, and other reactions—some potentially life-threatening. For example, in Rochester, NY, a faulty carbonation system on a soft drink machine continuously leaked carbon dioxide into the distribution system for over 3 months, creating increased levels of copper in the distribution system (as high as 13,400 ppb) (Manioci, 1984). Contamination at the K-25 atomic bomb plant in Oak Ridge, TN, occurred for an unknown length of time (possibly on the order of decades) through cross-connections with cooling system and firefighting lines. Contaminants found at the source of contamination that may have entered the distribution system included strontium-90, arsenic, chromium, and antifreeze (Nashville Tennessean, 2000).

Because few backflow incidents are reported, it is important to note that a variety of chemicals have the potential to enter the distribution system through cross-connections, and the number of those reported only represent a subset. For example, agricultural applications contain many fertilizers, herbicides, and insecticides and industrial sources such as cooling systems, plating plants, steam boiler plants, and dye plants have a number of toxic chemicals in day-to-day use that have the potential to contaminate the distribution system (USC FCCCHR, 1993). The most common chemical contaminants reported, according to information EPA has obtained from backflow incident records, are (in order of decreasing occurrence): copper, chromium, ethylene glycol, detergents, chlordane, malathion, propylene glycol, freon, and nitrite. Chlordane and malathion are pesticides; ethylene glycol is used as antifreeze in heating and cooling systems, propylene glycol is used as antifreeze and as a food additive; detergents are extensively used in many industries; copper is used in plumbing; chromium VI was used in the past in cooling towers as a rust and corrosion inhibitor; and nitrite is a reduced form of nitrate, an agricultural fertilizer. This summary discusses these and other related chemical contaminants (grouped into four categories—pesticides, metals, synthetic organic compounds, and nitrates and nitrites) in terms of potential health effects and examples of reported backflow incidents.

Pesticides

Pesticides (including insecticides, herbicides, and fungicides) as a group are contaminants in 45 reported incidents. Chlordane, malathion, heptachlor, and diazinon were reported as contaminants in 11, 5, 3, and 2 incidents, respectively. In one 1976 incident in Chattanooga, TN, chlordane was being used for termite extermination and contaminated a three-block area of residential homes; 17 people reported they drank the suspect water. Reported symptoms by those people were nausea, abdominal pain, gastrointestinal problems, and neurological effects such as dizziness, blurred vision, irritability, headache, paresthesia, muscle weakness, and twitching (AWWA PNWS, 1995). In 1980, heptachlor and chlordane contaminated a portion of distribution system in Allegheny, PA that serviced approximately 300 people. A pesticide contractor created the cross-connection with a garden hose submerged in the chemical mixing tank. There were no reports of illness, however, residents were without water for 27 days (Watts, 1998). Another pesticide incident involved diazinon contamination in Tucson, AZ in 1989. Diazinon entered the system through a residential connection where a home-made pesticide pump system was hooked up to a garden hose. The combination of backpressure from the pump system and the water use by a next-door neighbor washing a car caused the pesticide to flow into the distribution system (Tucson Citizen, 1989). No illnesses were reported. In 1986, two employees of a Kansas grain mill became ill after drinking water contaminated with malathion that was backsiphoned into the plant's water supply (AWWA PNWS, 1995). In 1988, a Florida man died of insecticide intoxication after he stepped off his mower, filled his water bottle, and drank from the bottle that was filled with contaminated water from a faucet at an airstrip. Officials suspected backflow as the cause of the water supply contamination (AWWA PNWS, 1995).

An example of a small amount of contamination resulting in a public health threat is a 1991 incident where 2.5 gallons of the herbicide TriMec backsiphoned into the Uintah Highlands water system in Utah affecting 2,000 homes (US EPA, 1989). Shortly thereafter, concentrations of the active ingredients, 2,4-D and Dicamba, at a consumer's tap were measured at 638 and 64.8 parts per million (ppm), respectively. This incident also affected a nursing home and a day-care facility, both of which serve higher risk subpopulations. The health advisory level of both 2,4-D and Dicamba over a 10-day period is 0.3 ppm (US EPA, 2000a). Chronic health effects of 2,4-D and Dicamba include damage to the nervous system, kidney, and liver (US EPA, 2002a). However, only acute exposures were documented.

Metals

There are 73 reported backflow incidents with metal contaminants—55 with copper and 18 with hexavalent chromium. Copper contamination is most commonly associated with backflow incidents at restaurants, where carbonated water can dissolve portions of water or soft drink dispenser piping made of copper. In 1987, a child in Minnesota suffered acute copper toxicity when the backflow from a carbon dioxide machine contaminated a restaurant's potable system (AWWA PNWS, 1995). A similar incident at a fair in Springfield, MO, caused vomiting and abdominal pain in three people who drank soft drinks from a soft drink machine that had a faulty check valve (AWWA PNWS, 1995). Potential health effects due to copper poisoning include vomiting, nausea, and liver and kidney damage; refer to the Chemical Health Effects Table for other potential health effects (US EPA, 2002a). CDC reports that the observed acute health effects due to copper poisoning outbreaks are gastrointestinal illness (CDC, 1996).

Chromium is used as a corrosion inhibitor. In 1970, a cross-connection between a chromate-treated cooling system and the water supply at Skidmore College in New York, New York, caused five people to become nauseated (USC FCCCHR, 1993). In another incident in New Jersey in 1970, hexavalent chromium contamination occurred through a cross-connection of a building heating system and soft drink machine causing 11 people to become nauseated (USC FCCCHR, 1993). Potential chronic health effects are listed in the Chemical Health Effects Table (US EPA, 2002a).

Synthetic and volatile organic compounds

Synthetic and volatile organic compounds as a group are contaminants in 66 reported incidents, with the most frequent contaminants being ethylene glycol (used in antifreeze), propylene glycol (used in antifreeze and as a food additive), freon (refrigerant), and propane (fuel).

Ethylene and propylene glycol were contaminants in 16 and 5 reported incidents, respectively. Examples include one incident in 1982, when ethylene glycol backsiphoned from an air conditioning system's water holding tank into a group of dialysis machines contributing to the death of "several" patients in Illinois (AWWA PNWS, 1995). In 1985, backpressure from a hospital air conditioning system caused the introduction of ethylene glycol into the water system of a New York hospital. One woman died after being exposed while undergoing dialysis (CDC, 1987). In 1987, a cross-connection with a heating system contaminated the plumbing at a municipal building in North Dakota with ethylene glycol, causing acute illness in 29 people. Water from a spigot used to make flavored drinks contained 9 percent ethylene glycol. Reported health effects included excessive fatigue and dizziness, while two children experienced vomiting, excessive fatigue, and hematuria (CDC, 1987). Backflow of propylene glycol from a fire suppression system in 1993 into the potable water system of a park in Arizona occurred for at least 2 months before the point of entry was identified. Several employees reported nausea and intestinal upsets after drinking water during the period of contamination (Watts, 1998), which was discovered by taste and odor complaints.

Freon and propane were contaminants in four and three reported incidents, respectively. In 1989, backpressure from a propane tank car forced propane into the water supply of Fordyce, Arkansas. Three people in separate buildings were injured from explosions after flushing toilets, and two houses were destroyed and a business was damaged by explosions and subsequent fires (AWWA PNWS, 1995). Backpressure from an air conditioning unit caused freon to backflow into the distribution system in Franklin, NE. The contamination was detected when city residents complained of bad tasting water that caused a burning sensation in the mouth (AWWA PNWS, 1995).

Detergents were contaminants in nine reported incidents. Contamination of concentrated soap in 1995 from an incorrectly installed soap dispenser at a health care facility in Iowa affected 13 people was reported a burning sensation in their mouths and symptoms resembling the flu (CDC, 1998). In 1993 in Seattle, WA a temporary cross-connection at a car wash facility allowed soapy water in the distribution system, affecting an eight block area and causing two unconfirmed cases of illness (AWWA PNWS, 1992).

Nitrates and nitrites

Nitrates and nitrites were contaminants in four reported incidents. Nitrate is a common ion found in natural waters and is used in fertilizers. Nitrite is typically not observed at significant levels (AWWA, 2001), however nitrate reduces to nitrite in the human body. In one incident in the county courthouse building of Monterey, CA, sodium nitrate from the boiler and cooler system backflowed into the potable water supply through a faulty backflow prevention device. Nineteen people became sick and needed medical attention from drinking coffee from the courthouse snack bar (AWWA PNWS, 1995). An incident of nitrite contamination at a school in California caused illness in three people; a faulty double-check valve allowed chemicals from the chilling system to enter the school's potable water system (CDC, 1998). Another backflow incident through a cross-connection with a boiler and a faulty backflow prevention device occurred in New Jersey, causing six people to become ill with methemoglobinemia caused by nitrites (CDC, 1998). Potential health effects of nitrate consumption include diuresis and hemorrhaging of the spleen, among others (US EPA, 2002a).

5.2.2 Biological Contaminants

The risks posed by backflow of biological contaminants vary dramatically depending on the disease vector, the concentration and degree of infectivity of the pathogen, the level of disinfectant residual maintained by the water system, and the health of the individual exposed (Rusin et al., 1997). Infective dose studies of non-primary (opportunistic) pathogens on healthy individuals and animals, using the oral and intranasal route, demonstrate that very high doses (e.g., for bacteria, 10^6 -10^{10} cells) are needed for infection or disease (Rusin et al., 1997).

Pathogenic microorganisms (e.g., *Giardia*, some strains of *E. coli*) have contaminated potable water supplies through cross-connections with sewer lines, untreated surface water sources, reclaimed water supplies, equipment at medical facilities and mortuaries, and utility sinks, pools, and similar receptacles. In addition, drain lines, laboratories, and illegal connections of private wells and cisterns to public water supplies are primary sources of contamination (USC FCCCHR, 1993).

A majority of microbial incident reports (32 of 58) list the microbial contaminant as "sewage" or nonspecific microbes. In the summer of 1990, 1,100 guests of a country club in Tennessee suffered intestinal disorders in two mass incidents after consuming the club's contaminated water supplied from an auxiliary well that had become contaminated with sewage due to a cross-connection (AWWA PNWS, 1995). In February, 1990, a cross-connection between an auxiliary irrigation system supporting a golf course and country club and the Seattle Water Department's distribution system resulted in total and fecal coliform contamination that was detected by neighboring systems purchasing water (AWWA PNWS, 1995). The health effects from pathogens are often not specifically reported in the incident reports, making it more difficult to determine the type of microbial contaminant. The combination of these reporting issues leads to underreporting of contamination linked to a specific pathogen.

The general health effects of most microbial pathogens include fever, nausea, and diarrhea, while some diseases have long-term and/or life-threatening effects. For example, the protozoan *Giardia* (a contaminant in 12 reported incidents) causes severe and potentially long-term diarrhea, accompanied by excessive gas, bloating, and weight loss. The Microbial Health Effects Table lists these general health effects and other potential diseases (US EPA, 2002b); however, the table is not all inclusive; additional potential health effects exist.

From backflow incident records collected by EPA, the most common microbial contaminants and their potential health effects are listed below with examples of backflow incidents.

Shigella

Shigella species are a cause of gastroenteritis, and are reported as contaminants in five incidents. The associated symptoms are vomiting, diarrhea, fever, and convulsions (US EPA, 2002b). All species of *Shigella* are highly infectious in humans and are spread through ingestion of fecal contamination (US FDA, 2001a). In one incident in 1977, a cross-connection led to four cases of shigellosis in an apartment house in Chicago, Illinois (USC FCCCHR, 1993). It is unknown whether the cross-connection spread *Shigella* into the distribution system.

E. coli

E. coli, a common biological contaminant (reported as a contaminant in two incidents) that is found in sewage, is normally a benign intestinal bacterium that is present in every human. However, some strains of *E. coli* are pathogenic, and can cause a variety of internal disorders. The most common effect is watery diarrhea, with some strains causing fever or dysentery. In rarer cases, some strains of *E. coli* can cause persistent diarrhea in young children, and have hemolytic properties. An infamous strain of *E. coli* is strain O157:H7, which, in addition to causing bloody diarrhea, can cause kidney failure (US EPA, 2002b). In 2000, two outbreaks of *E. coli* occurred in Medina County, OH, where approximately 30 became ill (Cleveland Plain Dealer, 2001).

Salmonella

Salmonella is one of the primary intestinal bacterial waterborne pathogens (reported as a contaminant in one incident). Depending on the strain, health effects can include typhoid fever, gastroenteritis (salmonellosis) (Benenson, 1995), and septicemia (US EPA, 2002b). In one incident, 750 people became ill with *Salmonella enteritidis* in Richland, Washington, in 1983. The incident involved new plumbing and contaminated ice (CDC, 1984). A person infected with the *Salmonella enteritidis* bacterium usually has fever, abdominal cramps, and diarrhea beginning 12 to 72 hours after consuming a contaminated food or beverage. The diarrhea can be severe, and the person may be ill enough to require hospitalization (CDC DBMD, 2001).

Campylobacter jejuni

Campylobacter jejuni is an avian gut bacteria that is the primary cause of bacterial diarrhea in the United States (CDC, 2002b). It is estimated that *Campylobacter* infects over two million people a year, and 10,000 cases are reported to the CDC annually, despite limited monitoring. Although *Campylobacter* is primarily a foodborne pathogen, it has been implicated in waterborne disease outbreaks in the past (CDC, 1996). This bacteria can cause gastroenteritis with symptoms including bloody diarrhea, fever, and abdominal cramping (US EPA, 2002b). In extreme cases, a *Campylobacter* infection may lead to Guillain-Barré syndrome where the immune system attacks part of the nervous system (CDC, 2002b). In 1986, 250 people became ill with diarrhea due to *Campylobacter* contamination in Noble, OK (CDC, 1996).

Cyanobacteria

Cyanobacteria are photosynthetic free-living bacteria. They produce algal blooms in fresh water, which can result in elevated toxin levels. Cyanobacterial toxins can produce acute neurotoxicity, hepatotoxicity, gastroenteritis, respiratory ailments, skin irritation, and allergic reactions through contact or ingestion (CDC, 2002c). In one incident in 1992, in Ritzville, Washington, backsiphonage from a drain sump near a new reservoir caused a reoccurring contamination of cyanobacteria (AWWA PNWS, 1995).

Norwalk and Norwalk-like viruses

The Norwalk family of viruses is a cause of viral gastroenteritis with symptoms of vomiting, diarrhea, upper respiratory problems, and fever (US EPA, 2002b). Although viral gastroenteritis is caused by a number of viruses, it is estimated that Norwalk or Norwalk-like viruses are responsible for about 1/3 of the cases of viral gastroenteritis not involving the 6-to-24-month age group (US FDA, 2001b). People often develop immunity to the Norwalk virus, however, it is not permanent and reinfection can occur (US FDA, 2001b). In developing countries the percentage of individuals who have developed immunity is very high at an early age. In the United States, the percentage increases gradually with age, reaching 50 percent in the part of the population over 18 years of age. Norwalk or Norwalk-like viruses were reported as a contaminant in two incidents. In one incident in 1980 in Lindale, Georgia, 1,500 people became ill with a Norwalk-like acute gastrointestinal illness as a result of a contamination incident for which the specific chemical or microbiological contaminant was never determined (CDC, 1982).

Giardia

Giardia was a contaminant in 12 reported incidents. *Giardia* are intestinal parasites that exist in natural waters in a nonreproductive stage (cysts). They can cause diarrhea, as well as vomiting, cramps, and bloating (US EPA, 2002b). The mode of infection is through ingestion of fecally contaminated food or water. The infections from these parasites are usually self-limiting, but among children, the elderly, and the immunocompromised, the infections can lead to chronic diarrhea, anemia, fever, and possibly death (Hoxie et al., 1997; US EPA, 1998; CDC, 2002a). In 1979, *Giardia* was responsible for 2,000 illnesses after backpressure effluent from a tree bubbler system in an Arizona State park (Lake Havasu) contaminated the potable water supply (USC FCCCHR, 1993). In 1994, dozens of people became ill from *Giardia* contamination through a cross-connection between a drain and an ice machine at a convention in Columbus, Ohio (AWWA PNWS, 1995).

Other contaminants

Biological contaminants that are nonmicrobial can also enter the distribution system. For example, due to a cross-connection at a funeral home, human blood and bodily fluids from the embalming process were backsiphoned into the distribution system, and blood flowed from water fountains and other water fixtures (US EPA, 1989). Human bodily fluids can be a vector for disease as well as being an aesthetic concern.

5.3 Data on Selected Backflow Incidents, 1970-1999

There are no reporting requirements nationally for backflow incidents, and no central repository for backflow incident information. Nonetheless, data on backflow incidents have been actively collected by several organizations, including the following:

- Centers for Disease Control (CDC), the federal agency that tracks epidemiology of illnesses as reported by doctors and health care providers.

- Cross-Connection Control Committee of the Pacific Northwest Section of the American Water Works Association (AWWA PNWS), a technical and educational association for the drinking water industry.

- University of Southern California's (USC's) Foundation for Cross-Connection Control and Hydraulic Research, a water engineering research and industry standards development organization.

- American Backflow Prevention Association (ABPA), a training and advocacy association for the water system industry.

Drawing from these and other sources, including EPA Regional Offices, the Florida Department of Environmental Protection, professional manuals on controlling cross-connections, and news reporting accounts, EPA compiled data on 459 backflow incidents that occurred in the United States between 1970 and 2001. Exhibit 5.1 summarizes the types of incidents reported at various sites and indicates the wide range of problems that can occur. Because backflow incidents are underreported, the data cannot support conclusions about the full magnitude of risk associated with backflow. And the exhibit summarizes only the reported acute health impacts, as surveillance programs do not capture impacts due to chronic exposures or chronic health effects.

Exhibit 5.1 Reported Backflow Incidents for Which EPA Has Compiled Data

Source of Contamination	Documented Incidents	Examples of Incidents
Residential Sites		
Homes With Individual Connections	55	• In 1991, an atmospheric vacuum breaker valve intended to protect a cross-connection between an irrigation system and the potable supply malfunctioned, allowing backflow of irrigation water into the public water system. The water system, located in Michigan, was contaminated with nematodes, rust, and debris (AWWA PNWS, 1995). • In 1997, recycled water reached approximately 1,600 California homes and businesses from a residential connection after a property owner illegally tapped into a reclaimed water line (California HHS Agency, 2001).
Apartment Buildings or Condominiums	27	• In 1981, chlordane and heptachlor were backsiphoned through a garden hose submerged in a termite exterminator's tank truck in Pennsylvania. An undisclosed number of illnesses occurred, and 75 apartment units were affected (NAPHCC, 1996). • In 1985, hexavalent chromium backflowed from a Boston, Massachusetts condominium's cooling tower into the potable water system (NAPHCC, 1996).
Mobile Homes or Mobile Home Parks	1	• In 1984, a leak developed in a wall separating solar water heater heat transfer medium from a residential water supply. The water supply of a mobile home in Oregon was contaminated with dichlorofluoromethane (AWWA PNWS, 1995).
Neighborhood	3	• In 1995, a business tapped into an irrigation line containing untreated water in Yakima, Washington, without installing a backflow prevention device. This allowed *Giardia* to contaminate area residences, resulting in 11 cases of giardiasis. (AWWA PNWS, 1995). • In 1997, a fire truck pump created backpressure on a fire hydrant before the valve was closed, forcing over 60 gallons of aqueous fire-fighting foam into an estimated 40,000 neighborhood taps in Charlotte-Mecklenburg, North Carolina (ABPA, 1999).

Exhibit 5.1 Reported Backflow Incidents for Which EPA Has Compiled Data

Source of Contamination	Documented Incidents	Examples of Incidents
Government and Institutional Sites		
Medical Sites (Hospital, Dental, Nursing Sites, Blood Banks, etc.)	27	• In 1982 in Illinois, ethylene glycol backsiphoned from an air conditioning system's water holding tank into a group of dialysis machines, contributing to the death of "several" (number not given) patients (AWWA PNWS, 1995). • During shut-down of a water main to repair a valve in 1984, the backflow of water from a nursing home's boiler caused burns to a water department employee's hands in Washington State (AWWA PNWS, 1995). • In 1994, during repairs to a nursing home air conditioning unit in Franklin, Nebraska, a hole left in the cooling coils allowed freon to backflow into the city water main, affecting the city's 1,100 residents. Customers complained about the taste of the water, but no illnesses were reported (AWWA PNWS, 1995).
Schools, Universities, and Children's Camps	31	• In 1990, six staff members of an Indiana middle school reported becoming ill after drinking water containing ethylene glycol that backflowed from the school's cooling system into the potable water system (AWWA PNWS, 1995). • In 1987, copper sediment contamination in a beverage mixing tank resulted in four cases of illness in a residence hall at Michigan university (AWWA PNWS, 1995). • In 1995, three people became ill at a California school after drinking water from a system with a double-check backflow prevention valve that did not meet industry standards and had badly deteriorated rubber gaskets (Craun and Calderon, 2001).
Public Water Systems	15	• In 1984, creosote was backsiphoned through a three-quarter inch hose used to prime a pump, contaminating a section of a Georgia community water system. No illnesses were reported (AWWA PNWS, 1995). • In 1970 in Mattoon, Illinois, hot wash water from an asphalt plant backpressured into mains during flow testing of fire hydrants (USC FCCCHR, 1993).

Exhibit 5.1 Reported Backflow Incidents for Which EPA Has Compiled Data

Source of Contamination	Documented Incidents	Examples of Incidents
Other Government/ Institutional Sites (e.g., public buildings, churches)	24	• In 1976, water fountains at the State Capitol building in Salem, Oregon, were contaminated with freon gas from a ruptured heat exchanger. The gas combined with the fluoride in the water supply, forming an acid compound that caused a bitter, burning taste (AWWA PNWS, 1995). • In 1991, two check valves froze open at a Texas Air Force base, resulting in a backflow from a water chiller; pathogenic bacteria were detected in the water. The specific contaminant was not identified. Approximately 22,000 workers and residents were without water during system flushing (AWWA PNWS, 1995). • In 1994, the water system at a Tennessee prison was cross-contaminated by the facility's wastewater pump station, resulting in 304 cases of giardiasis (Craun and Calderon, 2001). • Purified drinking water lines at the Oak Ridge Reservation's K-25 atomic bomb fuel plant were interconnected for an unknown length of time (possibly on the order of decades) with lines carrying impure creek water. The creek water contained poisons generated from nuclear fuel production, possibly including contaminants such as strontium-90 and arsenic (Nashville Tennessean, 2000).
Commercial Sites		
Restaurants	28	• In 1979, two high school students in Seattle, WA, became ill, showing symptoms of copper poisoning after drinking soft drinks from a dispensing machine in a restaurant. The backflow of carbon dioxide from the soft drink dispensing machine was considered the likely cause of the copper release (AWWA PNWS, 1995). • In 1987, a child in Minnesota suffered acute copper toxicity when backflow from a carbon dioxide machine contaminated a restaurant's potable system (AWWA PNWS, 1995).
Office Buildings	18	• In 1989, a backflow event at an Ohio government office building occurred after crews worked on the air conditioning system. Twelve individuals became ill after ingesting water that had been contaminated with Acid Blue 9, an algae-retarding chemical (AWWA PNWS, 1995). • In 1991, trichloroethane entered the distribution system of a city in Missouri from a newspaper office. Uncoordinated flushing by the water system caused the contaminant to spread throughout the system, with concentrations as high as 420 micrograms/L (AWWA PNWS, 1995).

Exhibit 5.1 Reported Backflow Incidents for Which EPA Has Compiled Data

Source of Contamination	Documented Incidents	Examples of Incidents
Other Commercial Sites	66	• In 1974, backsiphonage of a chromium compound from the chiller water of an air conditioning system contaminated the drinking water system in the auditorium hosting the 94th annual AWWA conference and exhibition in Massachusetts, involving thousands of people (AWWA PNWS, 1995). • In 1990, 1,100 guests of a Tennessee racquet and country club became ill with an intestinal disorder after consuming the club's contaminated water supplied from an unauthorized and unprotected auxiliary well in close proximity to a malfunctioning sewage pumping station (AWWA PNWS, 1995). • In 1994, a number of individuals attending an Ohio convention got sick with giardiasis, spread by an ice machine contaminated by a cross-connection to a sewage drain (AWWA PNWS, 1995).
Miscellaneous Sites		
Agricultural Sites	6	• In 1991, an antibiotic solution used at a commercial chicken house entered an Arkansas public water system as a result of a cross-connection between an auxiliary well connected to the chicken house plumbing (AWWA PNWS, 1995). • In 1995, pesticides (paraquat and atrazine) were backsiphoned into a distribution system when an accidental water main cut occurred while a Louisiana farmer was diluting herbicides in a tank. Some people reported nausea, stomach burns and pains, profuse sweating, diarrhea, and shortness of breath. The incident was the subject of a class-action lawsuit (AWWA PNWS, 1995).
Recreational Sites	10	• In 1986 in Springfield, MO, failure of a single check valve on a soft drink dispensing machine at a local fair resulted in the backflow of carbon dioxide that created levels of 2.7 mg/L of copper and 2.2 mg/L of zinc. Three people experienced vomiting and abdominal pain (AWWA PNWS, 1995). • In 2000, contaminated water lines at an Ohio fairground resulted in an outbreak of *E. coli*, resulting in 30 cases of illness (Cleveland Plain Dealer, 2001).

Exhibit 5.1 Reported Backflow Incidents for Which EPA Has Compiled Data

Source of Contamination	Documented Incidents	Examples of Incidents
Industrial Sites	40	• In 1989, backpressure from a propane tank car forced propane into the water supply of Fordyce, Arkansas. Three people in separate buildings were injured from explosions after flushing toilets, and two houses were destroyed and a business was damaged by explosions and subsequent fires (AWWA PNWS, 1995). • In 1990, at least two individuals became ill after an unknown quantity of industrial chemicals backflowed into the public water supply via an unprotected auxiliary line illegally tapped to a hose connected to the plant's flushing system. The incident occurred at a New Mexico facility that transforms wheat and barley into ethanol (AWWA PNWS, 1995).
Other Sites/Site Type Unknown	108	• In 1980, a cross-connection aboard an Alaskan crab processing ship resulted in backflow of sewage (including *Giardia*), causing 189 employees to become ill and endangering about $35 million worth of processed king crab (USC FCCCHR, 1993; CDC, 1982).
Total	459	

Source: CDC, AWWA PNWS, ABPA, EPA, USC FCCCHR, FDEP, and Newspapers

5.4 Occurrence of Cross-Connections and Backflow

From a 1999 American Backflow Prevention Association (ABPA) survey, ABPA estimated that 42 percent of cross-connection surveys conducted (by 135 respondents, representing 30 states) identified a cross-connection. The most common cross-connections reported were from irrigation (62 percent of respondents identified an irrigation cross-connection), fire systems (43 percent), garden/washdown hoses (43 percent), and boilers (38 percent). A total of 233 backflow incidents were reported by 51 percent of respondents, or 1.7 incidents per system (ABPA, 1999). These numbers only reflect those backflow incidents detected; many go undetected because it is not practical for systems to continuously monitor their distribution systems for changes in pressure or the presence of contaminants. In addition, ABPA conducted a survey in 2000, which included a question on the occurrence of low pressure events which may lead to backflow where unprotected. A survey of 70 systems responding to the survey reported 11,186 pressure reduction incidents in the previous year; 34.8% of the incidents were from routine flushing, 19.2% were due to main breaks, and 16.2% of the incidents were due to service line breaks (ABPA, 2000).

5.5 Difficulties in Detecting Backflow Incidents and Associated Outbreaks

Contamination due to backflow incidents may not be detected or reported for several reasons:

- Bacterial contamination tends to be transient and highly localized (ABPA, 1999).

- Water system operators monitor routinely for coliform bacteria, however, most often that is the only microbial monitoring conducted (US EPA, 2001). While these bacteria are important indicators of distribution system problems, some microbial contaminants may go undetected. The limited nature of biological monitoring, especially in smaller systems (as infrequent as once per year), makes it unlikely that contamination will be detected in a timely manner. Operators monitor for a limited number of chemicals (US EPA, 2001), but not routinely or often enough to identify most backflow incidents.

- Most backflow incidents are generally detected and reported to the local authority only if customers detect an irregularity in their water supply. Not all contamination that produces illness and disease can be detected by taste, color, or odor (Hoxie et al., 1997). For many highly toxic substances, including benzene, vinyl chloride, and dichloromethane, the taste and odor threshold is well above the drinking water maximum contaminant level (MCL) (DWI0441, 1992; Glaza and Park, 1992).

- Even if an irregularity is detected, it may not be reported by the consumer.

- When water system operators suspect backflow incidents, they have a disincentive to document and report them because of concerns about legal liability and loss of consumer confidence, as noted by an EPA Office of the Inspector General report (US EPA, 1995). (Fortunately, these same concerns provide the utility with an incentive to protect the distribution system.)

- The difference between epidemic and endemic transmission is obscured by limitations in recognizing when an outbreak occurs (Frost et al., 1996). A study of waterborne cryptosporidiosis estimates that out of every 10,000 infections by *Cryptosporidium* only 3 would be reported, and concludes that surveillance for detected cases of a reportable illness may substantially underestimate rates of infection and morbidity (Perz et al., 1998).

- Some contaminants that enter the distribution system through cross-connections and backflow may not be reportable.

- The incidents of reduced pressure and some cross-connections are often transient in nature. Pressure changes may not be detected by conventional pressure monitoring equipment. Reduced pressures may also affect only a portion of the distribution system, a specific pressure zone, or only piping beyond the service connection.

State officials offer perspective on the estimated extent of underreporting. One State official suspects that there may be 10 times as many as incidents as are reported (Fauver, 2002). Another State official estimates approximately 1,200 backflow incidents occur per year, assuming that all water main breaks will cause a backflow incident (and each of 600 public water systems in the State average 2 water main breaks a year). Yet only 15 backflow incidents have been documented in the State since 1970 (Koenig, 2002).

Outbreaks of illness associated with backflow incidents also are underreported, for the following reasons:

- Outbreaks of illness may not be linked to an incident of backflow contamination (Craun and Calderon, 2001). Documented effects of contamination are usually acute and result from short-term exposures; whether mild or severe, the effect appears soon after exposure. Effects that are long-lasting or only appear after some time (chronic effects) are difficult to ascribe to a single event or associate with a waterborne source. Cross-connections combined with uncorrected backflow situations that cause continuous or intermittent exposure over a long time and result in chronic illness would be less likely to be linked to backflow contamination.

- Contamination may not affect enough people to attract the attention of public health officials (Craun and Calderon, 2001).

- Information that could tie an incident to an outbreak of illness or disease, such as where and when a contaminant entered the system, is often missing.

Even when incidents are detected and voluntarily reported, inconsistent reporting and documentation procedures make it hard to assess the full scope of the problem. Some organizations that record incidents will accept reports only if they have documentation that meets their standards. The USC FCCCHR prepared a *Summary of Case Histories* (USC FCCCHR, 1993) that covers 397 incidents from 1903 to 1993. The Chief Engineer of the Foundation estimated that more than 90 percent of the backflow incidents known to water system administrators were not documented enough to be included in the case histories (CCC WS, 1999). Inadequate documentation can result from the fact that where backflow is suspected, in most instances it is difficult if not impossible to trace the origin of contamination (BMI, 1999).

6.0 Costs of Backflow Contamination Incidents

The costs associated with backflow incidents depend on the nature and scope of the incident and the nature and extent of the response. Depending on these factors, costs could be incurred for public notification; the repair of damage to water distribution system infrastructure; investigation, sampling, and laboratory analysis; clean-up of structures and equipment; purchases of bottled water; responding to consumer complaints; lawsuits (both legal fees and judgments); the repair of property damage; replacement of spoiled food; missed work and school; loss of production; and medical expenses. Beyond actual costs, other losses could include leisure time and even mortality.

The ABPA 1999 survey gathered information to estimate the costs water systems may incur to mitigate a backflow incident. The survey collected data from 25 water systems serving fewer than 10,000 people and from 103 systems serving 10,000 people or more. Survey results show that for the 92 systems that responded, water system operators expended an average of 494 hours per event mitigating backflow incidents. At $30 per hour (the average rate of technical labor reported by the Bureau of Labor Statistics (2000)), that averages $14,800 per event. Eleven of these were significantly more time consuming than the others, averaging 3,683 hours and about $110,500 (at $30 per hour) per incident. Excluding these 11 most time-consuming incidents, operators expended an average of 60.8 hours per incident and $1,820 per incident. Utility-level costs such as these do not include costs for all of the possible elements described earlier, especially those for health-related effects.

Other backflow incidents reported monetary losses due to food spoilage, property damage, and lawsuits. Examples include a backflow of wastewater through a cross-connection created with the water supply and the wastewater line when a new well was installed; the wastewater contaminated pork valued at approximately $2 million (NAPHCC, 1996). A lawsuit for $21 million was filed against a pest control company that contaminated the water supply to 63 homes and businesses with pesticide; the money was compensation for physical distress, inconvenience (the homes and businesses were without water for several days), and loss of property value (AWWA PNWS, 1992).

7.0 Other Problems Associated with Backflow Incidents

This section discusses other negative effects associated with cross-connections and backflow that, although not a direct threat to health, can cause other undesired effects such as negative publicity, consumer complaints, damage to the water system, and impediments to system operation. Negative effects discussed are: 1.) corrosion; 2.) microbial growth; and 3.) taste, odor, and color problems.

Corrosion

Many contaminants, such as acids and carbon dioxide, can corrode pipes and other distribution system materials. Many incidents of corrosion induced by carbon dioxide backflow have released toxic amounts of copper into drinking water systems (AWWA PNWS, 1995). Many of these incidents were reported because the corrosion was rapid enough and large enough in extent to produce concentrations of corroded metal high enough to be toxic or to lead to complaints about taste and odor.

Corrosion in iron pipes is much less likely to be noticed because iron is not as toxic as copper, and corrosion of iron and steel is relatively slow, leading to lower concentrations. But slow corrosion is a problem: corroded iron pipes can lead to discolored water, stained laundry, and taste complaints (McNeil and Edwards, 2001). Corrosion can also weaken the integrity of pipes, causing leaks that can allow contaminants in through intrusion or catastrophic breaks, which can in turn cause reduced pressure (McNeil and Edwards, 2001). Corrosion of iron pipes can also form tubercles that can shelter microbes (including pathogens) from disinfection (US EPA, 1992).

Microbial growth

When backflow through cross-connections introduces microbes into the distribution system, these organisms can attach to pipe walls in places where the disinfectant residual may be inadequate to inactivate the microbes, such as in dead ends. Such organisms, even if they are not pathogenic themselves, can be a concern because they can colonize on the pipe walls, forming biofilms (US EPA, 1992) that trap and concentrate nutrients, promoting growth of pathogens (Costerton and Lappin-Scott, 1989). The biofilm can lead to total coliform violations, even in the absence of contamination events. Biofilm can also cause complaints about taste and odor and harbor potentially pathogenic organisms from disinfection (Characklis, 1988). Backflow through cross-connections can also introduce nutrients that support the growth of pre-existing biofilms.

Taste, odor, and color problems

Some contaminants introduced through cross-connections and backflow may not cause illness but may result in consumer complaints about the tastes, odors, or color of the water (e.g., seawater and dyes (AWWA PNWS, 1995)). Such incidents can lower consumer confidence in the water system, require water and employee time to flush the system to remove the offending contaminant, and initiate an investigation to identify and correct the cross-connection.

8.0 Suitable Measures for Preventing and Correcting Problems Caused by Cross-Connections and Backflow

This section reviews existing research, data, and available information regarding the prevention of cross-connections and backflow incidents, as well as mitigation measures systems use following a backflow incident.

8.1 Preventive Measures

Backflow into the public water distribution system can be prevented by eliminating cross-connections or protecting the potable water supply using backflow prevention devices and assemblies. Some systems educate the public to prevent cross-connections, and maintain and inspect the distribution system to correct those found. However, because situations frequently arise where new cross-connections occur before they are detected and corrected, it is helpful to build in to the distribution system physical impediments to backflow, including mechanical backflow prevention devices and assemblies. Systems look to minimize the risk posed to their distribution systems from a customer's plumbing system, and therefore conduct hazard assessments in order to determine the level of protection needed and what approach should be taken. The appropriate type of protection depends on the physical characteristics of the cross-connection (e.g., whether there is a potential for backpressure in addition to backsiphonage) and the degree of the potential hazard. The degree of hazard is a function of both the probability that backflow may occur and the toxicity or pathogenicity of the contaminant involved. A high hazard can be defined as,

> "a condition, device, or practice which is conducive to the introduction of waterborne disease organisms, or harmful chemical, physical, or radioactive substances into a public water system, and which presents an unreasonable risk to health" (BMI, 1996).

Low hazard can be defined as,

> "a hazard that could cause aesthetic problems or have a detrimental secondary effect on the quality of the public potable water supply" (BMI, 1996).

Another reason for conducting risk assessments is to determine and help manage legal liability due to public health risk; therefore, these definitions of high and low hazard are ultimately subjective and depend upon the risk aversion of the water system, appropriate local regulations, and the particular risk assessment conducted by the system.

8.1.1 Physical Separation

Air gaps, if designed and maintained properly, make backflow physically impossible as they ensure that there is no connection between the supply main and the nonpotable source. An effective air gap is a physical separation of a supply pipe from the overflow rim of a receiving receptacle, by at least twice the diameter (minimum of one inch) of the incoming supply pipe (USC FCCCHR, 1993; BMI, 1996). The distance between the end of a faucet and the overflow of a utility sink is an example of an air gap. While air gaps provide physical assurances against backflow, they are often tampered with as people extend the end of the pipe to prevent splashing and thus potentially create a cross-connection. By the AWWA standard, air gaps are acceptable in lieu of mechanical backflow prevention assemblies beyond the service connection only if installed and maintained by the local cross-connection control program enforcement agency (AWWA, 1999).

8.1.2 Backflow Prevention Devices and Assemblies

Mechanical backflow prevention devices and assemblies offer protection of the potable water system if other protective approaches fail. Backflow prevention devices and assemblies may be installed at the service connection to a facility (effectively "containing" a potential contaminant within a customer's plumbing system and preventing it from entering the distribution system). Alternatively, devices and assemblies can also be installed at high and low hazard cross-connections inside the facility, including all outlets where cross-connections could potentially be created (this type of approach is called "isolation" or "fixture outlet protection"). Some drinking water authorities prefer isolation to containment because personnel working beyond the service connection are protected and, in most cases, the assembly can be sized smaller because of smaller piping beyond the service connection. However, backflow devices and assemblies used for isolation could be bypassed through changes to internal plumbing, inadvertently creating an unprotected cross-connection.

There are two types of mechanical protection available to systems: backflow prevention "devices" and backflow prevention "assemblies". Backflow prevention devices function by stopping the reversal of flow, but are not testable once installed because they do not have inlet and outlet shut-off valves or test cocks (USC FCCCHR, 1993). Backflow prevention assemblies, by contrast, include an inlet and outlet shut-off valve and test cocks to facilitate testing of the assembly while it is in its functional environment (in-line) (USC FCCCHR, 1993).

Backflow prevention assemblies include pressure vacuum breakers (PVBs), spill resistant vacuum breakers (SVBs), double check valve assemblies (DCVAs), and reduced pressure principle backflow assemblies (RPs) (USC FCCCHR, 1993) (BMI, 1996). PVBs are vertically positioned assemblies that include spring-loaded check valves designed to close when flow stops (USC FCCCHR, 1993). They also have an air inlet valve that is designed to open when the internal pressure is lower than the atmospheric pressure, preventing backsiphonage but not backpressure. PVBs must be a minimum of 12 inches above all downstream piping and the flood level rim of a receptor to function properly. PVBs are designed to protect against low- or high-hazard situations.

SVBs are similar in design to PVBs with the addition of a diaphragm seal that stops water from spilling out the air inlet whenever the assembly is pressurized. As with PVBs, they protect against backsiphonage only (BMI, 1996).

A DCVA consists of two internally loaded, independently operating check valves together with tightly closing resilient seated shut-off valves upstream and downstream from the check valves (USC FCCCHR, 1993). These assemblies require a minimum of 1 foot of clearance at the bottom for maintenance purposes to allow for the worker to get to the assembly. These assemblies are used for protection against either backsiphonage or backpressure, but only for situations of low hazard.

RPs consist of two internally loaded, independently operating check valves and a mechanically independent, hydraulically dependent relief valve located between the check valves (USC FCCCHR, 1993). The relief valve maintains a zone of reduced pressure between the two check valves. The RP also has tightly closing, resilient seated shut-off valves upstream and downstream of the water supply. RPs must have a minimum of 1 foot clearance at the bottom of the assembly for maintenance purposes. RPs protect against backsiphonage or backpressure in low- or high-hazard situations.

One common backflow prevention device is an atmospheric vacuum breaker (AVB). AVBs rely on atmospheric instead of water pressure to work, and are installed downstream from all shut-off valves.

AVBs contain an air inlet valve that closes when the water flows in the normal direction. But, as water ceases to flow, the air inlet valve opens and prevents backsiphonage. AVBs must be a minimum of 6 inches above all downstream piping and the flood level rim of a receptor to function properly (USC FCCCHR, 1993). Household hose bib vacuum breakers and frost-proof wall hydrant faucets are examples of AVBs. According to some, AVBs do not protect against backpressure and are used in situations of low hazard (BMI, 1999); however, some plumbing codes recognize AVBs as high hazard assemblies.

The selection of any particular assembly or device is a function of the hazard assessment that balances the likelihood of backpressure and backsiphonage and the potential contaminants involved. The total cost of installing and maintaining a particular device or assembly can also be a factor for some water systems. In cases of low hazard and backsiphonage only, systems typically install less expensive AVBs or PVBs. If backpressure is a concern, many systems use double check valve assemblies, and if the degree of hazard is high, many systems install a reduced pressure principle backflow assembly.

The cost of backflow preventers has been reported by industry experts to be a deterrent in starting and maintaining and backflow prevention program (CCC WS, 1999). The cost of backflow preventers can range from $18 to over $22,000 (Watts, 2002), depending on the size and preventer type. Installation costs are typically borne by the water system and passed along to consumers, or are borne directly by consumers (ABPA, 2000).

8.1.3 Cross-Connection Control and Backflow Prevention Programs

Many states and local jurisdictions require cross-connection control and backflow prevention programs. However, many utilities do not have programs, or have programs that are insufficient to provide reasonable protection from cross-connections (ABPA, 1999). The program requirements vary widely between states: they may be part one or more of various regulations, including the drinking water regulations, health code, plumbing code, policy decision of the utility itself and building codes. A 1993 U.S. General Accounting Office report on the review of 200 sanitary surveys and a nationwide questionnaire of states identified inadequate cross-connection control programs as the most common deficiency (US GAO, 1993).

Programs and their level of effort are often tailored to the perceived risk of backflow and the types of hazards that can be introduced into the distribution system (USC FCCCHR, 1993). These factors may contribute to determining whether a containment or isolation program is implemented locally, as well as what types of backflow preventers are required. The need for backflow prevention in a water system is determined through a variety of means, including: surveys of new sites; retrofit programs; and change of occupancy inspections. Some programs inspect a site upon request. In many of these cases, identification of hazards determines the need for backflow prevention. For example, Kansas City, Missouri's program does informal, informational checks and passes the data to the plumbing authority (Nelson, 1999). The cross-connection control programs of Boston and Cambridge, Massachusetts, check connections to the last free-flowing tap (Hendrickson, 1999). Other programs, such as the one for Gatlinburg, Tennessee, identify additional requirements as a function of the risk of the facility (City of Gatlinburg, 2001). The water system in Price, Utah, performs about 20-30 inspections each year, about half of which go beyond containment to focus on potential cross-connection hazards. Staff focus primarily on high-hazard sites, but inspect other types of sites after installations or upgrades (Price, 1999).

In an effort to evaluate the measures states take to address cross-connections and backflow, EPA analyzed existing state requirements (Exhibit 8.1). The analysis reviewed regulations of all states pertaining to drinking water, clean water, and plumbing and building codes. Additionally, information from the following surveys was used as supplementary information for the analysis: the EPA Office of Inspector General Report (The Survey Report on the Cross-Connection Control Program, 1995); the Florida Report (The State of Florida's Evaluation of Cross-Connection Control Rules/Regulations in the 50 States, FDEP, 1996); Governmental Affairs Committee (GAC) Follow-up Survey (Summary of the Cross-Connection Control Requirements-Nationally, 1997); the American Backflow Prevention Association (ABPA) Survey, 1999; the Association of State Drinking Water Administrators (ASDWA) Survey, 1999; and the Van Loon Survey, 1999.

Exhibit 8.1. State Cross-Connection Control Requirements

Requirement	Number of States With Requirement
Does the State have a requirement for the control of cross-connections and/or backflow prevention?	50
Is it specified in the requirement that the system must implement or develop a cross-connection control and/or backflow prevention program?	32
Does the State require authority to implement a local ordinance or rule for cross-connection control and/or backflow prevention?	33
- Must the authority cover testing of backflow prevention assemblies?	27
- Must the authority cover the use of only licensed or certified backflow assembly testers?	16
- Must the authority cover the entry of the premises for the sake of inspecting the premises?	14
- Must the authority cover the entry of the premises for the sake of inspecting and/or installing backflow prevention assemblies?	15
Does the State require training, licensing, or certification of backflow prevention assembly testers?	26
Does the State require training, licensing, or certification of backflow prevention assembly and/or device installers?	6
Does the State require training, licensing, or certification of backflow prevention assembly and/or device repairers?	10
Does the State require training, licensing, or certification of cross-connection control inspectors?	19
Does the State require inspection of backflow prevention devices and/or testing of backflow prevention assemblies?	37
Does the State require the system to include record keeping as part of cross-connection control?	34
Does the requirement include keeping records of hazard assessment surveys?	11
Does the State require the system to notify the public following the occurrence of a backflow event?	3
Does the state require the local rule or ordinance to allow the system to take enforcement action against customers that do not comply with the cross-connection control and backflow prevention requirements?	23
Does the State conduct periodic reviews of cross-connection control programs?	3
Does the State regulation or plumbing code require public education regarding cross-connection control and/or backflow prevention?	7

Source: Derived from state drinking water and clean water regulations and state plumbing and building codes.

Considerable variability exists in state statutes, regulations, and policies related to cross-connection control and backflow prevention. In some cases where states do not require programs, some water systems within the state have implemented comprehensive and active programs in absence of a state requirement to do so.

According to input from a Cross-Connection Control Expert Meeting in September, 1999, a program is considered active and comprehensive if it contained regulations with these requirements: 1) require adoption of some form of legal authority (ordinance, by-law, code) for establishing and maintaining a cross-connection control program at the local level; 2) require training and certification specifications; 3) require record keeping and reporting; 4) provides public education; and 5) define enforcement responsibility and penalties. Many state programs that require cross-connection control and backflow prevention programs share these elements (ASDWA, 1999; USC FCCCHR, 1993). As noted in Exhibit 8.1, several states have these requirements, although a majority do not have all five of the recommended minimum elements.

Authority

Experts agreed that a cross-connection control program should have the authority to effectively enforce its ordinances and requirements (CCC WS, 1999). It is recommended by groups such as the AWWA (AWWA, 1999) that local cross-connection control programs have the legal authority in place to carry out basic program requirements, such as: 1) enter premises and inspect facilities to determine the degree of hazard and the presence of cross-connections; 2) to install, repair, and test backflow devices; 3) license employees or contractors engaged in testing of assemblies to ensure competency; and 4) terminate water service in case of noncompliance. Not all states require authority to effectively enforce the ordinances and requirements—33 states require local authorities to implement cross-connection control ordinances. Of those states, only 14 states require authority to enter premises for inspection purposes, and 15 states require authority to enter premises to inspect or install backflow prevention devices (Exhibit 8.1).

Different local authorities may have pre-existing responsibilities that would be overlapped by a cross-connection control program. Water utilities typically have the responsibility to protect the distribution system up to a customer's meter. In some cases, they fulfill this responsibility by placing backflow assemblies at the meter (USC FCCCHR, 1993). Plumbing authorities are often responsible for all potable water connections downstream of the meter (USC FCCCHR, 1993). Engineers and building authorities have inspection and compliance responsibilities which, in some cases, overlap with plumbing authorities. Additional overlap of authority occurs with regard to fire lines. While fire lines can use potable water and are frequently interconnected with the potable system (AWWA, 1999), they are usually unmetered and typically not considered part of the drinking water supply, and therefore are not subject to plumbing codes. Having backflow assemblies on fire lines (e.g., the Boston, Massachusetts, program involving the fire authorities) requires the cooperation of fire departments. In addition, many programs require customers to understand the dangers of backflow and take effective measures to eliminate, fix, and isolate cross-connections.

Training and certification

Training and certification is considered an important element of a cross-connection control and backflow prevention program (CCC WS, 1999). The training and certification can cover administering a program, conducting site surveys, installing and testing approved backflow assemblies, as well as for maintaining and repairing backflow assemblies. The testing of backflow prevention assemblies by a certified tester works to ensure that the assembly is functioning properly and will prevent backflow.

Twenty-six states require certification of backflow assembly testers (Exhibit 8.1). In some states, backflow assembly testers also install and repair the backflow preventers, however only 6 states require training, licensing, or certification of backflow installers (Exhibit 8.1). A small number of states expand their training requirements to program managers, installers, and/or repairers. Nineteen states require certification of survey inspectors (Exhibit 8.1).

Having trained and certified testers may contribute to effective cross-connection control and backflow prevention. For example, in 1998, a 42-inch water main broke in close proximity to the Boston Public Library, causing a dramatic drop in pressure in a large portion of the city for a short period; however, there were no reported backflow incidents (Hendrickson, 1999). The key elements of the Boston, Massachusetts, cross-connection control and backflow prevention program include 11 full-time cross-connection control staff employees, all of whom are certified testers licensed by the State of Massachusetts (Hendrickson, 1999).

Public education

There have been incidents of water system customers installing inadvertent cross-connections leading to backflow incidents. Education of the public may reduce the number of cross-connections created on the customer side, and is therefore a critical element in the implementation and success of a cross-connection control and backflow prevention program (CCC WS, 1999). Seven states required public education regarding cross-connection and/or backflow control and prevention (Exhibit 8.1). Public education is usually a function of the local water purveyor. Also, states sometimes provide materials for distribution, and maintain Internet sites that include information about state water quality programs to educate consumers about CCC programs and the role they play in protecting their drinking water. The Michigan Backflow Prevention Association has developed a video used for training utility personnel on educating the public (MBPA, 1997).

Educational tools used by local programs are: meetings, brochures, and seminars. Las Vegas, Nevada, has run multiple seminars to explain the program since they serve two jurisdictions (Blish, 1999). They have been so successful that some of the large casinos now have their own on-site trained and certified cross-connection control personnel. Tucson, Arizona distributes backflow prevention brochures to customers, and in the past has used public access television to promote the program. They also distribute backflow prevention brochures to existing customers during inspections (Adams, 1999). Other programs distribute fliers and bill inserts. The public awareness program of Sandy City, Utah, consists of fact sheets, manufacturer's information on backflow prevention, newspaper articles and newsletters, public meetings with customers, and backflow information provided to people requesting information on sprinkler systems (Oakeson, 1999).

Reporting and record keeping

A requirement to report backflow incidents is important for detection and correction of cross-connections (CCC WS, 1999). Although many backflow incidents are believed to occur undetected, those that are detected can provide valuable information on other potential cross-connections in the distribution system. Three states require reporting of backflow incidents to the public, while eight states require systems to notify state authorities (Exhibit 8.1).

Lack of records or poorly organized records can inhibit corrective measures. Thirty-four states require some sort of record keeping as part of their cross-connection control and backflow prevention program (Exhibit 8.1). As part of its cross-connection control program, Tucson, Arizona, has a data management system that tracks each assembly's compliance status (Adams, 1999). The Charlotte-

Mecklenburg incident involving firefighting foam, which took 39 hours and 100 city employees to remedy, prompted the state to require a comprehensive evaluation of the Charlotte-Mecklenburg Utility Department's backflow prevention program by an outside consultant. One of the key findings resulting from the evaluation was that the program did not have a formal retrofit program for existing connections and devoted excessive resources to record keeping; the resources spent on record keeping were used inefficiently. Since then, the utility has implemented a new data management system to reduce the record keeping burden and plans to hire an additional staff member to focus on developing a program for retrofitted equipment (ABPA, 1999).

Testing and repair

Many systems that have cross-connection control and backflow prevention programs require testing to ensure that backflow preventers are working correctly. As in any mechanical device, backflow assemblies can deteriorate and fail as they get older. Testing intervals typically are annual, semi-annual, or risk-based (USC FCCCHR, 1993).

Many states require in regulation or code specific components that make up a testing program. A testing program frequently identifies the appropriate standards that a backflow prevention device or assembly must meet (e.g., standards set by the USC FCCCHR, AWWA, or in the Uniform Plumbing Code (UPC)), as well as specifies a routine testing frequency to ensure adequate performance of the devices. In many cases, assemblies are then tested by a certified backflow assembly tester. Approximately 37 states require inspection and/or testing of various backflow assemblies in their regulations (Exhibit 8.1).

In Boston, Massachusetts, as required by the state, reduced pressure backflow assemblies are tested twice a year; double-check valve assemblies are tested once per year (Hendrickson, 1999). The program performs 11,000 site inspections per year. All surveys go to the last free-flowing outlet regardless of whether the facility is considered high- or low-hazard, as required by state cross-connection control regulations. Under this program, 100 percent of all high-hazard sites have installed protection. This high level of testing has prevented any cross-connection incident since 1984, and no boil-water notices have been necessary (Hendrickson, 1999).

Enforcement

AWWA recommends that cross-connection control program authority should include clearly defined enforcement procedures such as provisions to shut off water service if devices are not installed or tested, entry to property is not allowed, devices and assemblies are not installed properly, devices are not tested, and testing payments are not received (AWWA, 1999). According to the 1995 EPA Office of Inspector General report, state officials indicated that they adopted a regulation prohibiting cross-connections and required the local water suppliers to establish a program with the responsibility to administer and enforce the program at the local level (US EPA, 1995). State officials indicated, however, that there is little follow-up or enforcement at the state level (US EPA, 1995). In addition, several states do not require systems to develop programs to implement or enforce the requirements, through additional drinking water regulations, plumbing codes, or health codes. For example, only 23 states require enforcement action against noncomplying customers (Exhibit 8.1). In Denver, Colorado, enforcement consists of notifying customers that backflow assemblies must be installed. Customers are then given 90 days to comply, followed by a second notice, 30 days of grace, and then third notice. Failure to comply may lead to suspension of water service. Inspections are done by request and number approximately 25 per month (Stevens, 1999). Thirty-two states require water systems to have a CCC program, but only three states conduct periodic reviews of cross-connection control programs, and these reviews are conducted annually (Exhibit 8.1).

8.1.4 Disinfectant Residual

While not able to prevent cross-connections or backflow from occurring, the use of disinfectant residuals (i.e., free chlorine or chloramines) can provide a measure of protection against waterborne disease through the inactivation of some microbial or oxidation of some chemical contaminants. Although contamination from cross-connections and backflow may be controlled by a disinfectant residual (Snead et al., 1980), some water supply professionals believe a disinfectant residual is not effective when cross-connections result in massive contamination (LeChevallier, 1999). In some cases, reductions in a disinfectant residual can signify the existence of a contamination problem in the distribution system, including those resulting from cross-connections and backflow (Haas, 1999). However, some disinfectant residual sampling strategies (e.g., grab samples), may not be able to detect a reduction in disinfectant residual concentrations for transient events, such as many backflow incidents.

8.1.5 Pressure Stabilization and Maintenance of Positive Pressure

Since backsiphonage and possibly backpressure are induced by drops in distribution system pressure, maintaining positive and stable pressure reduces the risk of backflow. Minimizing pressure spikes through use of variable speed pumps and proper valve opening and closing procedures may reduce the frequency of main breaks that cause backsiphonage (Kirmeyer et al, 2001), and thus be a preventive measure. Maintaining positive pressure through changes in pumping patterns and adding additional pump power can minimize backsiphonage and may reduce the occurrence of backpressure events (Kirmeyer et al, 2001). Pressure stabilization and pressure maintenance may be difficult for systems with multiple entry points and those with large variances in elevation or daily demand. Main breaks, firefighting demands, or other unusual demands that cannot be predicted will also hinder a system's ability to maintain pressure.

The initial design of a distribution system can minimize possible cross-connection and backflow opportunities by avoiding low pressure areas and ensuring positive pressure throughout the system. Water systems that are aware of pressure drops within their distribution systems can conduct additional water quality testing to determine if a backflow incident has occurred, thus detecting incidents that may have gone undetected. Systems that have records of pressure over a period of time have the ability to identify chronic trouble spots, and the records can provide information to devise a strategy to fix them (LeChevallier et al, 2001). Studying and correcting low pressure zones in existing systems, either continual or transient, can reduce the number of backflow incidents (LeChevallier et al., 2001).

8.1.6 Pipeline Maintenance and Inspection

Regular inspection of pipelines may identify conditions that could lead to main breaks such as frozen valves, advanced corrosion, and small leaks, and allow them to be repaired before they lead to main breaks, which can lead to backsiphonage. Regularly cleaning and flushing pipelines may also reduce buildup and growth of biofilms that may promote corrosive conditions that can cause pipeline leaks and eventually breaks (Shindala and Chisolm, 1970; Norris and Ryker, 1987).

8.1.7 Sanitary Surveys

Through the course of conducting sanitary surveys on elements related to the distribution system, likely cross-connections may be identified and corrected by the water system (US EPA, 1999). Sanitary surveys may also find evidence of corroding pipelines, frozen valves, and other situations that could lead to pressure maintenance problems.

8.1.8 Standards and Codes

The plumbing codes adopted by states are represented in Exhibit 8.2. In addition to the plumbing codes listed in the exhibit, AWWA also provides guidelines and standards (AWWA, 1999). Some areas of the country use plumbing codes to set standards, as well as cross-connection control and backflow prevention programs. The plumbing standards used by many localities can be found in the Uniform Plumbing Code, the International Plumbing Code, the Building Officials and Code Administration, and the Southern Building Code Congress International. However, plumbing codes are often only enforceable against plumbers and property owners, and not public water systems themselves.

Exhibit 8.2 Plumbing Codes Adopted by States

Plumbing Code	Number of States Adopting
Statewide Code	47
No Statewide Code	3
Statewide Codes Adopted	
Uniform Plumbing Code	14
State Code	7
International Plumbing Code	5
National Standard Plumbing Code	4
Southern Building Code Congress International	4
Other	13

Source: NAPHCC Survey (1999), IAPMO Plumbing Code Adoption Map (2001)

8.2 Corrective Measures

This section describes methods used by water systems to correct contamination from cross-connection and backflow incidents once they have been detected, as well as minimize resulting problems. Corrective actions that systems conduct following detection of an incident include: 1) isolation of the contaminated area; 2) public notification; 3) flushing and cleaning the system; and 4) pipeline replacement.

8.2.1 Isolation of the Contaminated Area

If preventive measures fail and a backflow contamination event occurs, systems frequently respond by trying to limit the damage and remove the contaminant from the system. When a system learns of a contamination event, many systems isolate the portion of the system that was contaminated to prevent the contamination from spreading. The response to a 1982 propane gas leak in a town in Connecticut was to first evacuate residents and seal off the affected area (AWWA PNWS, 1995). This is achieved by shutting off valves surrounding the contaminated area. Crews generally start at the point where the contamination was reported and work their way out until they find the edge of the contamination. Contaminants that are not detectable through sight or smell may be difficult to track and contain if field testing techniques for the contaminant are not available. Because a stuck valve can prevent an area from being isolated and lead to the spread of contamination, valve exercising programs can be important in isolating contamination events. In 1988, in response to a backflow incident at a paint factory in Edgewater, Florida, the factory manager isolated the factory water system from the city water system prior to flushing out the contaminants (USC FCCCHR, 1993). An example of not being able to isolate the area is the Charlotte-Mecklenburg incident (Exhibit 5.1), which required 90 million gallons to flush the distribution system (ABPA, 1999).

8.2.2 Public Notification

If a contamination event has occurred and the contamination was unable to be isolated before reaching customers, all customers served by the system must be notified (65 FR 25982). The type of notification depends on the contaminant and the size of the area contaminated (65 FR 25982). If the contaminant has acute health effects notification must be as quick as possible, either through broadcast media or through system employees or public safety officials going door-to-door depending on the size of the area. For contaminants without immediate or short-term health effects, the public can be notified by other methods such as letters placed in mail boxes or print media (65 FR 25982). Notification of the public can prevent health effects by minimizing possible contact with contaminated water until other immediate corrective measures have been completed. During the Charlotte-Mecklenburg incident (Exhibit 5.1), the city coordinated an emergency response and notified 40,000 affected customers. In a 25-block radius from the incident, door-to-door notifications were made instructing customers not to use their water. An extended area beyond the door-to-door radius was notified through media reports not to use their water (ABPA, 1999).

8.2.3 System Flushing and Cleaning

Once a contamination event has been detected and isolated, usually water system authorities flush the system as a first attempt to remove the contaminant. Flushing is done by opening up hydrants and expelling water from the system using a wide open valve approach until the contaminant can no longer be detected. If a large area has been affected several hydrants may need to be opened in succession to clean the system. Flushing generally moves from the source of contamination in the downstream direction. If the source of contamination is not found and fixed there is a possibility of a repeat incident. In 1986, after sodium hydroxide contaminated the distribution system of Lacey's Chapel, Alabama, water mains and affected plumbing were flushed after containment (Watts, 1998). Valves are then slowly opened before the hydrant is turned off. This allows for the removal of any contamination that was undetected during system isolation and may have moved beyond the valves used for isolation (Yoke and Gittelman, 1986). Out of 28 backflow incidents on which EPA has information and where a response was reported, 12 reported flushing the affected portion of the distribution system.

Some contaminants may not be adequately removed by flushing. Microbial contaminants may concentrate in biofilms that may not be easily dislodged by flushing alone. The water system serving Muncie, Indiana, drained its entire distribution system over a weekend in an unsuccessful effort to remove the biofilm (Geldreich, 1996). Other contaminants may adsorb to biofilm layers or corroded pipe materials and be released slowly to water in the pipe and, therefore, may take an unreasonable amount of time to flush from the system (US EPA, 1992). In these cases, water systems may opt to physically clean the pipelines. Pigging and rodding are cleaning methods where a device is introduced into the pipe that physically scrapes biofilm and corrosion layers from the sides of the pipe (Kirmeyer et al, 2001). Jetting and sandblasting can also be used to remove such layers. Typically pipes are disinfected and flushed after a physical cleaning by one of the above methods.

8.2.4 Pipeline Replacement

Some contaminants may not be removed by physical cleaning. Examples include the pesticide chlordane, which can adsorb to even clean pipe material and is released into solution only at slow rates. In 1987, following contamination of drinking water lines in Fairlawn and Hawthorn, New Jersey, with the pesticides chlordane and heptachlor, the affected lines were removed and replaced (AWWA PNWS, 1995). Radioactive materials are also difficult to remove physically as they can irradiate pipe materials. Other contaminants such as highly corrosive or explosive contaminants may cause damage to the system. In these cases, systems may choose to replace the contaminated piping and other appurtenances.

9.0 Possible Indicators of a Backflow Incident

This section discusses events, occurrences, or signals that help indicate to a water system or regulatory authority that a backflow incident is occurring or has occurred. A problem for water systems in detecting cross-connections is that there is little immediate warning that a backflow incident is occurring. In some cases it is not known for some time after an incident, and in other cases it is never discovered. With an active monitoring program, cross-connections may be detected by routine inspection, and deficiencies in the distribution system that could lead to backflow could be corrected. However, the efficacy of a cross-connection control program might only be known to the extent that new backflow incidents are not detected. Possible indicators of backflow include: 1) customer complaints of water quality; 2) drops in operating pressure; 3) drops in disinfectant residual; 4) water meters running in reverse; and 5) coliform detections. It is also possible that cross-connections and contamination due to backflow events can occur in the absence of these indicators.

Customer complaints

From the backflow incident data collected (Exhibit 5.1), the primary indicator of backflow has been customer complaints of odor, discoloration of the water, or direct physical harm from contact with the water. Generally, it is unknown how long a backflow incident may have occurred before it is detected through aesthetic or health concerns.

Drops in operating pressure

Continual monitoring for reduced pressure can give immediate warning of a potential backflow incident. It may also identify the area where a pressure drop may have originated, and thus help isolate areas affected by backflow. A drop in operating pressure can only indicate that a backflow event may have already occurred; it cannot stop an event in progress or prevent an incident, unless the root cause is corrected.

Drops in Disinfectant Residual

A drop in the disinfectant residual of a distribution system can be an indicator of a backflow event. Many factors influence the concentration of the disinfectant residual in the distribution system, including the assimilable organic carbon level, the type and concentration of disinfectant, water temperature, and system hydraulics (Trussell, 1999). Entry of foreign material into the distribution system from backflow (or other events) may alter these factors and contribute to a loss of residual.

Water meters running in reverse

During periods of reversed water flow, water meters can reverse their counters. When investigating a water quality complaint at a restaurant in Kennewick, WA, a cross-connection specialist found the meter at the site running backwards; the dual check valves for the carbon dioxide tanks were impaired, allowing the pressurized carbon dioxide to backflow into the water supply line (AWWA PNWS, 1995). Based on a survey of water systems, many have the ability to detect meters running backwards and have detected this occurrence on several occasions (Schwartz, 2002).

Total coliform detections and heterotrophic plate count changes

A sudden spike in total coliform detections, or a sudden change in heterotrophic bacterial densities (measured by heterotrophic plate count) is an indication that contaminants could have entered the distribution system (40 CFR 141). Persistent coliform contamination may indicate a long-standing cross-connection. Monitoring for coliform and other microbial indicators of contamination, as well as more extensive monitoring, may help identify instances of backflow contamination.

10.0 Research Opportunities

This document identifies what we know regarding the potential health risks associated with cross-connections and backflow incidents in drinking water distribution systems based on available literature, research, and information. However, as with most areas, further opportunities exist for research to result in greater certainty of the health impacts associated with drinking water distribution systems. Some specific research opportunities, among others, related to cross-connections and backflow are: further analysis of how surges contribute to occurrence of backflow; the degree of underreporting of backflow incidents across the country; what constitutes an effective cross-connection control and backflow prevention program; and what the effectiveness of disinfectant residual is for protecting against microbial contamination from backflow. It is not feasible to list all specific data needs for cross-connection control and backflow prevention, but two reports being prepared for EPA as part of its Comprehensive Drinking Water Research Strategy and the Microbial/Disinfection Byproducts (M/DBP) Research Council outline additional research opportunities.

11.0 Summary

Cross-connections and backflow represent a significant public health risk (US EPA, 2000b) by allowing chemical and biological contaminants into the potable water supply (a conclusion of the Microbial/Disinfection Byproducts Federal Advisory Committee (M/DBP FACA)). Of the 459 backflow incidents from 1970-2001 on which EPA has information, an estimated 12,093 cases of illness resulted. Fifty-seven of these cross-connection-related waterborne disease outbreaks were reported to CDC from 1981-1998, and resulted in at least 9,734 cases of illness. A wide number and range of chemical and biological contaminants have been reported to enter the distribution system through cross-connections and backflow. Pesticides, sewage, antifreeze, coolants, and detergents were the most frequent types of contaminants reported. Although a wide range of contaminants have been reported, the number on contamination incidents is considered a likely underestimate due to problems in detecting, reporting, and documenting incidents. These problems include: an inability to detect incidents without health effects; incidents with health effects that are unreported because affected individuals do not realize a connection between their illness and the drinking water; no requirement on either health officials or water system officials to report detected backflow incidents; and no central repository for reported illness. Where undetected, cross-connections may also expose consumers to contaminants from backflow long-term. Cross-connections can be prevented through mechanical means and through programs administered by local or state officials to specifically locate and eliminate cross-connections and prevent backflow. Officials can also take measures to correct deficiencies that either have the potential to lead to backflow incidents or have already caused a backflow incident, and they can increase monitoring for indicators of potential problems to improve reaction time to future incidents.

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Notice: This product requires annual inspection, maintenance and cleaning to ensure proper function and maximum life.

Maintenance

1. Close inlet and outlet shut-off valves before disassembling device.
2. Remove canopy screws counterclockwise and remove canopy.
3. Bleed off pressure by opening the No. 2 test cock.
4. Unscrew the bonnet from the body by turning counterclockwise.
5. Remove the disc & poppet assembly, check spring and spider assembly from body.
6. Clean all parts with clean water only.
7. After completing inspection, replace necessary parts and reassemble. Repair kits are available from your supplier.
8. Retest according to "TEST PROCEDURES".

Testing Procedures

TEST NO. 1

Purpose: To test the opening pressure differential of the air inlet valve.
Requirement: The air inlet valve shall open when the pressure in the body is no less than 1.0 psi above atmospheric pressure. The air inlet valve shall be fully open when the water drains from the body.

STEPS:

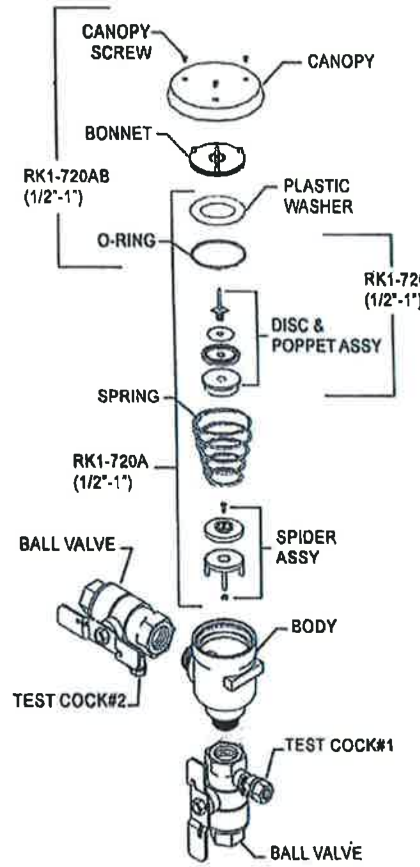
1. Bleed water through both test cocks to eliminate foreign material.
2. Install appropriate fittings for test kit hoses.
3. Remove air inlet valve canopy.
4. Install the high side hose of the differential pressure gauge to test cock #2. Open test cock #2 and bleed air from hose and gauge.
5. Close #2 shut-off valve then close #1 shut-off valve.
6. Slowly open the high side bleed needle valve being especially careful not to drop the pressure differential too fast. Record the pressure differential at which the air inlet valve opens.
7. Close test cock #2 and remove equipment.
8. Open #1 shut-off valve.

TEST NO. 2

Purpose: To test the check valve for tightness in the direction of flow.
Requirement: The check valve shall be drip-tight in the normal direction of flow when the inlet pressure is 1.0 psi and the outlet pressure is atmospheric.

STEPS:

1. Attach high side hose of differential gauge to test cock #1. Open test cock #1 and bleed all air from the hose and the gauge by opening high side bleed needle valve. Close high side bleed needle valve.
2. Close #1 shut-off valve.
3. Open test cock #2. The air inlet valve will open and the water in the body will drain out through test cock #2. When this flow of water stops, the differential pressure indicated by the gauge after it has settled will be the pressure drop across the check valve. This value must be 1.0 psi or greater. Record this value. If water continues to flow out of test cock #2, then the #1 shut-off valve is leaking.
4. Close test cocks #1 and #2 and remove equipment.
5. Replace air inlet valve canopy.
6. Open #1 shut-off valve, then #2 shut-off valve.



Troubleshooting

PROBLEM	POSSIBLE CAUSES
Air inlet valve does not open as gauge drops to 0.0 psid.	1. Air inlet disc stuck to seat. 2. "Old Style" pressure vacuum breaker (non-loaded air inlet valve).
Air inlet valve does not open and differential on gauge will not drop.	1. Leaking No. 1 shut-off valve. 2. Parallel installation with leaky No. 2 shut-off valve.
Air inlet opens below 1.0 psid.	1. Dirty or damaged air inlet disc. 2. Scale buildup on seat.
Check valve opens below 1.0 psid.	1. Dirty or damaged air inlet disc. 2. Damaged seat.

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Limited Warranty: Watts Regulator Co. (the "Company") warrants each product to be free from defects in material and workmanship under normal usage for a period of one year from the date of original shipment. In the event of such defects within the warranty period, the Company will, at its option, replace or recondition the product without charge.

THE WARRANTY SET FORTH HEREIN IS GIVEN EXPRESSLY AND IS THE ONLY WARRANTY GIVEN BY THE COMPANY WITH RESPECT TO THE PRODUCT. THE COMPANY MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED. THE COMPANY HEREBY SPECIFICALLY DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

The remedy described in the first paragraph of this warranty shall constitute the sole and exclusive remedy for breach of warranty, and the Company shall not be responsible for any incidental, special or consequential damages, including without limitation, lost profits or the cost of repairing or replacing other property which is damaged if this product does not work properly, other costs resulting from labor charges, delays, vandalism, negligence, fouling caused by foreign material, damage from adverse water conditions, chemical, or any other circumstances over which the Company has no control. This warranty shall be invalidated by any abuse, misuse, misapplication, improper installation or improper maintenance or alteration of the product.

Some States do not allow limitations on how long an implied warranty lasts, and some States do not allow the exclusion or limitation of incidental or consequential damages. Therefore the above limitations may not apply to you. This Limited Warranty gives you specific legal rights, and you may have other rights that vary from State to State. You should consult applicable state laws to determine your rights. **SO FAR AS IS CONSISTENT WITH APPLICABLE STATE LAW, ANY IMPLIED WARRANTIES THAT MAY NOT BE DISCLAIMED, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED IN DURATION TO ONE YEAR FROM THE DATE OF ORIGINAL SHIPMENT.**

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RP/IS-800M4QT 1529 EDP# 1915087

ENGLISH INSTRUCTIONS

⚠ WARNING

Read this Manual BEFORE using this equipment.

Failure to read and follow all safety and use information can result in death, serious personal injury, property damage, or damage to the equipment.

Keep this Manual for future reference.

⚠ WARNING

Local building or plumbing codes may require modifications to the information provided. You are required to consult the local building and plumbing codes prior to installation. If the information provided here is not consistent with local building or plumbing codes, the local codes should be followed. This product must be installed by a licensed contractor in accordance with local codes and ordinances.

⚠ WARNING

Need for Periodic Inspection/Maintenance: This product must be tested periodically in compliance with local codes, but at least once per year or more as service conditions warrant. All products must be retested once maintenance has been performed. Corrosive water conditions and/or unauthorized adjustments or repair could render the product ineffective for the service intended. Regular checking and cleaning of the product's internal and external components helps assure maximum life and proper product function.

Testing

For field testing procedure, refer to Watts installation sheets IS-TK-DP/DL, IS-TK-9A, IS-TK-99E and IS-TK-99D found on **Watts.com.**

For other repair kits and service parts, refer to our Backflow Prevention Products Repair Kits & Service Parts price list PL-RP-BPD found on **Watts.com.**

For technical assistance, contact your local Watts representative.

Pressure — Temperature

Working Temperature: 33°F - 140°F (0.5°C - 60°C)
Maximum Pressure: 150psi (10.3 bar)
Minimum Pressure: 15psi (103 kPa)

Installation

Requirements:

1. Install 12" (305mm) above highest point of downstream piping see Fig. 1.
2. Install bonnet side up and allow for accessibility for testing/service.
3. Install where discharge or spillage is not objectionable.
4. Do not undersize supply or oversize the valve in relation to demand.
5. Do not install where backpressure can occur.
6. Protect from freezing - for Freeze Protection specify Model 800M4FR or LF800M4FR. Freeze protection can also be provided using a WattsBox insulated enclosure. Send for ES-WB for additional information.
7. ASSE Standard 1020 requires that the atmospheric vent valve remains open until the valve body pressure exceeds 1 lb. Until this pressure is reached, some amount of spillage will occur at the atmospheric vent. In order to minimize this leakage on **start-up** close the down stream shutoff valve and open inlet shutoff valve quickly.

Start Up Procedure

1. Close #2 (outlet) shutoff
2. Slowly open #1 (inlet) shutoff until water comes out bonnet then quickly open to pressurize valve.
3. Open #2 shutoff

Service:

1. Open test cocks to drain in cold climates if only operated seasonally.
2. **Replace** rubber goods every 5 years.

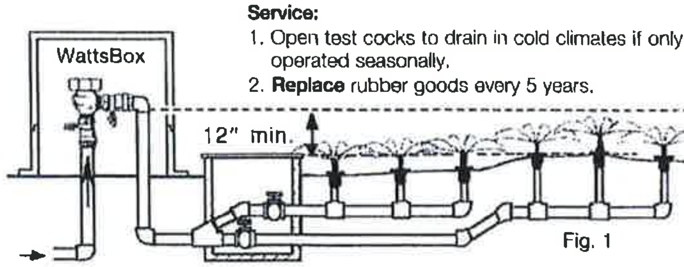

Fig. 1

SHAKOPEE PUBLIC UTILITIES COMMISSION
RESOLUTION NO. 2024-30

A RESOLUTION MAKING FINDINGS OF FACT AND DETERMNING THE APPEAL SUBMITTED BY MIKHAIL STALMAKOV

WHEREAS, Shakopee Public Utilities (SPU) has received by correspondence dated August 9, 2024, an appeal to the Shakopee Public Utilities Commission (the Commission), appealing a determination by the SPU General Manager denying Mikhail Stalmakov's (the "Customer") request to remove a $150 penalty for failing to comply with SPU's backflow prevention policy.

WHERAS, SPU oversees protection of the public water in the City of Shakopee. To address potential contamination of the public water supply, the Commission adopted a Backflow Prevention and Cross-Connection Control Policy (the "Policy"). The Policy requires testing of backflow preventer assemblies upon installation and then at intervals not to exceed twelve months from the previous test. A customer must provide proof of the required testing. On May 6, 2024, the Commission adopted the backflow penalty schedule for violation of the Policy, including a $150 penalty applicable one time during each 12-month testing period. This penalty is refundable if requested by a customer following a successful test submission within sixty days of the original due date, or if a customer requests an irrigation system lock-out by SPU in lieu of an annual backflow device test.

WHEREAS, the Customer failed to provide proof of testing and SPU imposed a $150 penalty. The Customer appealed this penalty to the SPU General Manager Greg Drent by correspondence dated July 30, 2024. Mr. Drent responded by letter dated August 8, 2024, denying the request to remove the penalty. The Customer requested an appeal to the Commission, and appeared at the September 9, 2024 Commission meeting

WHEREAS, the Customer submitted documents to SPU consisting of:

1. Customer's letter to Mr. Drent dated July 30, 2024

2. Minnesota Department of Labor & Industry communication entitled "What you need to know about backflow protection and fire sprinkler systems in the new 2015 Minnesota Plumbing Code"

3. Minnesota Department of Labor and Industry Fact Sheet entitled "Backflow Devices 2020 Minnesota Plumbing Code"

4. A portion of Customer's bill from SPU referencing water charges from June 7, 2024 through July 9, 2024 and including a $150 line item for Backflow Testing Penalty.

5. A letter from Mr. Drent to residents dated March 29, 2023.

6. Customer's correspondence to Mr. Drent dated August 9, 2024 requesting to appear before the Commission.

WHEREAS, SPU staff submitted information to the Commission consisting of:

1. SPU Backflow Prevention and Cross-Connection Control Policy (https://shakopeeutilities.com/wp-content/uploads/2022/08/Backflow-Prevention-and-Cross-Connection-Control-Policy.pdf).

2. SPU backflow prevention penalty schedule adopted May 6, 2024

3. Letter from Mr. Drent to the Customer dated August 8, 2024

4. SPU Staff memo dated October 2, 20224

5. Minn. Admin. R. 4714.0603; 4720.0025

6. 2020 Minnesota Plumbing Code, Chapter 6, (https://epubs.iapmo.org/2020/MPC/).

7. Environmental Protection Agency, *Distribution System Water Quality* (Oct. 2021)

8. Environmental Protection Agency, *Cross-Connection Control: A Best Practices Guide* (Sept. 2006)

9. Environmental Protection Agency, *Cross-Connection Control Manual* (2003)

10. Environmental Protection Agency, *Potential Contamination Due to Cross-Connections and Backflow and the Associated Health Risks* (Sept. 27, 2001)

NOW THEREFORE BASED UPON THE RECORD BEFORE THE COMMISSION AND ALL OF THE FILES, RECORDS, AND PROCEEDINGS HEREIN, THE COMMISSION MAKES THE FOLLOWING:

FINDINGS OF FACT

1. The Policy requires testing of backflow preventer assemblies upon installation and then at least every twelve months from the last test. A customer must provide proof of testing by a certified American Society of Sanitary Engineers (ASSE) tester to SPU. Policy, §5.1, 5.2. The Commission adopted penalties for failure to comply with the Policy on May 6, 2024.

2. In his correspondence dated July 30, 2024 and at the September 9, 2024 Commission meeting, the Customer did not dispute that he has not complied with the Policy or that he failed to complete and submit the backflow prevention device testing for his lawn sprinkler system. Instead, the Customer presented three arguments against the penalty. First, the Customer stated that

Section 603.5 passed in 2015 refers to "fire sprinkler systems but not to garden sprinklers systems." Second, he reasoned that "there is no way for water to come to the city water through pipes from garden sprinklers" because "there is no back pressure" after the sprinkler is turned off. Third, the Customer noted that the State testing requirements apply to devices "installed in 2016 or later" but not beforehand. The Commission addresses each of these contentions.

3. The Commission determines that Minnesota requirements expressly apply to sprinkler systems. The 2020 Minnesota Plumbing Code, Section 603.5.6, entitled "Protection from Lawn Sprinklers and Irrigation Systems" specifically addresses lawn sprinkler systems, stating that "Potable water supplies to systems having no pumps or connections for pumping equipment . . . .shall be protected from backflow from one of the following devices" listing four permissible devices. It is incorrect that backflow prevention devices are limited to fire sprinkler systems.

4. The Customer presented no evidence or documents to support his comments that there is "no way" for backflow to occur from a lawn sprinkler system to the public water system. The Customer focused on his irrigation system. The federal Environmental Protection Agency (EPA), however, explained that a pressure difference may occur on either side of the connection: "Any interconnected fluid systems in which the pressure of one exceeds the pressure of the other may have flow from one to the other as a result of the pressure differential." EPA *Cross-Connection Control Manual*, at 15 (2003). In other words, the difference in pressure may occur on the public water system. "[D]ifferential pressure may occur when pressure in the potable [public water] system drops, for some reason, to a pressure lower than that in the system to which the potable [public] water is connected." *Id.*; EPA *Cross-Connection Control: A Best Practices Guide*, at 2 (Sept. 2006) (stating "in any distribution system, potential cross-connections and therefore sources of contamination can be numerous, varied, and unpredictable."); EPA *Potential Contamination Due to Cross-Connections and Backflow and the Associated Health Risks*, §4.2 (Sept. 27, 2001) (noting variety of potential causes of reduced pressures that may lead to cross-connection or backflow).

5. The EPA has reported contamination from E. coli and other contaminants arising from a lawn or irrigation system that was not protected by an appropriate backflow prevention device. EPA *Distribution System Water Quality* (Oct. 2021) (noting customer-created E. coli contamination from irrigation line without backflow prevention device); EPA *Cross-Connection Control: A Best Practices Guide*, at 1 (Sept. 2006) (noting that backflow examples include residential watering system flowing "into indoor plumbing and potentially into the distribution system."); EPA *Potential Contamination Due to Cross-Connections and Backflow and the Associated Health Risks*, §5.4 (Sept. 27, 2001) (stating that in 1999 study, irrigation was identified as the most common cause of cross-connections reported); §4.1 (noting residential lawn sprinkler spread parasitic worms into two homes after a water main break); §5 (collecting cross-connection and backflow incidents).

6. In addition, SPU staff reports that tests of backflow prevention devices of SPU customers have resulted in a 33.9% failure rate; in 2023, 87 systems failed out of 231 systems tested and in 2024, 103 systems failed out of 341 systems tested. These failures provide support for regular testing. The Commission remains committed to safeguarding the public water system from

potential contaminants. Even if lawn sprinkler systems provide a remote risk of contamination, it still happens, and SPU must comply with Minnesota requirements.

7. The Commission determines that Minnesota requires testing of backflow prevention devices upon installation and then annually. Minnesota Administrative Rule 4714.0603, subpart 1 is not limited to devices installed after 2016; the Rule states:

> Subpart 1. Section 603.2. UPC [Uniform Plumbing Code] section 603.2 is amended to read as follows:
>
> 603.2 Approval of Devices or Assemblies. Before a device or an assembly is installed for the prevention of backflow, it shall have first been approved. Devices or assemblies shall be tested in accordance with recognized standards or other approved standards. Backflow prevention devices and assemblies shall comply with Table 603.2, except for specific applications and provisions as stated in sections 603.5.1 through 603.5.23.
>
> Devices or assemblies installed in a potable water supply system for protection against backflow shall be maintained in good working condition by the person or persons having control of such devices or assemblies. ***The devices or assemblies shall be tested at the time of installation, repair, or relocation and not less than on an annual schedule thereafter, or more often*** where required by the Authority Having Jurisdiction. Where found to be defective or inoperative, the device or assembly shall be repaired or replaced. No device or assembly shall be removed from use or relocated, or other device or assembly substituted, without the approval of the Authority Having Jurisdiction.
>
> Testing shall be performed by a certified backflow assembly tester in accordance with ASSE Series 5000.
>
> UPC Table 603.2 is not amended. (Minn. Admin. R. 4714.0603, subp. 1) (emphasis added).

8. The Commission determines that Minnesota backflow prevention requirements are not limited to devices installed after 2016. To the extent that information from the Minnesota Department of Labor and Industry references 2016, it appears to be inconsistent with the current requirements in Rule 4714.0603, subp. 1. In any event, the language of the regulation governs.

BE IT RESOLVED BY THE SHAKOPEE PUBLIC UTILITIES COMMISSION AS FOLLOWS:

That the request of Mr. Stalmakov to remove the $150 penalty for his failure to comply with SPU's Backflow Prevention and Cross-Connection Control Policy is denied.

Passed in regular session of the Shakopee Public Utilities Commission this ________ th day of

_______________, 2024.

_______________________________________.
Commission Vice President: BJ Letourneau

ATTEST:

_______________________________.
Commission Secretary: Greg Drent

6c

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SHAKOPEE PUBLIC UTILITIES
MEMORANDUM

TO: Greg Drent, General Manager
Joseph Adams, Engineering Director

FROM: Ryan Halverson, Water Engineering Supervisor

SUBJECT: McGuire and Sunset Streets and Utilities Feasibility Report

DATE: September 16, 2024

ISSUE

The City of Shakopee is developing a feasibility report for the reconstruction of the roadways of McGuire Circle, McGuire Court and Sunset Circle. The feasibility report will also include a preliminary analysis of the how the project area could be served by the SPU water system. The Commission should discuss its' Water Policy Manual and the requirements necessary to serve the area.

BACKGROUND

The City of Shakopee Capital Improvement Plan includes a proposed 2025 project to reconstruct the roadways of McGuire Circle, McGuire Court and Sunset Circle. City staff has consulted with Stantec engineering group, to develop a feasibility report for the project, which typically includes many factors, such as: preliminary design, geological and environmental considerations, sanitary sewer and water main utilities, budget impacts and resident feedback and communications.

As part of the preliminary engineering analysis, City staff sent mailed surveys to the twelve property owners affected by the proposed project, asking residents if they had interest in the extension of sanitary sewer and water main to serve the area. The survey results showed that the twelve property owners of McGuire Circle and McGuire Court were interested in learning more about the infrastructure requirements, construction costs and connection fees related to hooking up to City sanitary sewer and SPU water main. The majority of the seven residents surveyed along Sunset Court were not interested in hooking up to sanitary sewer or water main at this time. Therefore, the feasibility report will not evaluate extending sanitary sewer or watermain to the properties adjacent to Sunset Court. Additionally, other properties in the area that are

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adjacent to Horizon Drive and Muhlenhardt Road were not considered or evaluated for municipal utilities in the feasibility report as the roadways are relatively new and extension of utilities would typically be considered during similar road reconstruction.

DISCUSSION

SPU staff has worked with City staff and its' consultant to develop a preliminary water main layout to serve the properties along McGuire Court and McGuire Circle area, in accordance with the SPU Water Policy Manual (See attached Exhibit A).

The watermain in the project area is proposed to be 8-inch water main. Per policy, a 10-inch pipe would be required to meet flow, but not needed due to the low density of the housing in the project area. This is supported by water pressure modeling done by SEH INC., as part of SPU's recent update to the Comprehensive Water Plan. The project area includes homes in both the Normal Elevation Service Zone (NES) and the High Elevation Service Zone (HES). A connection between the NES and HES zones would occur at the intersection of McGuire Circle and McGuire Court. A pressure reducing valve would be needed just north of the intersection.

To meet all lateral watermain design criteria, including looping, the homes along McGuire Court exist in the HES zone and would require an 8-inch water main from the project area heading east to the SPU Booster Station at CSAH16/CSAH18/Kelley Circle. Additionally, an additional 8-inch line from the McGuire Circle south along Muhlenhardt Road to the intersection of Horizon Drive, and a 12-inch oversized water main pipe along Horizon Drive from Muhlenhardt Road heading east across CSAH18 and connecting to the water system in Whispering Oaks neighborhood is required, or an 8-inch water main could be extended from McGuire Circle south along Muhlenhardt Road to a location approximately 575-feet south of Horizon Drive where the SMSC is proposing to construct an 8-inch watermain to serve a future Healing Center.

Both looping options would pass by several residential properties and a church/school property which are not being considered by the City for connection to utilities at this time. SPU would need to carry this cost initially and establish an equivalent lateral watermain fee that applies to these properties and needs to be paid prior to connection.

Stantec has provided two construction cost estimates for the proposed water main improvements:

- BASE WATER SERVICE (See Attached Exhibit B) is the construction cost to provide service to all of the properties in the project area, with looping south along Muhlenhardt to the 8-inch connection south of Horizon Drive. The estimated construction cost for the BASE WATER SERVICE is $1,040,00. This would cost each of the twelve lots $86,667.
- HIGH PRESSURE WATER LOOP (See Attached Exhibit C) provides the water main looping requirement for the HES zone. The estimated construction cost for the HIGH PRESSURE WATER LOOP is $470,925.00 This would cost each of the twelve lots $39,243.75.

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It should be noted, that in addition to the direct construction costs of the project, property owners would pay water connection fees, including both the Water Capacity Charge and Trunk Water Charge Fees, similar to any other property receiving water service in Shakopee:

- The 2024 rate for SPU Water Capacity Charge Fee is $5,693 per SAC unit. All of the properties in the project area are single family homes, which would get a 1-unit determination.
- The 2024 Trunk Water Charge Fee is $5,359 per developable acre. Lots in the project area average 2.4 acres in size. The project area would generate approximately $152,000 in Trunk Water Charge revenue for the system.
- The combined TWC and WCC would average $23,500 per lot.

Property owners would also be required to hire their own plumber to extend the water service from near the roadway into their home, establish an SPU water service account, place an account deposit, pay for a water meter and apply for a water connection permit.

FUNDING

All of the cost associated with constructing the proposed improvements would be paid for by the City of Shakopee, special assessments to benefitting properties and the remaining watermain costs funded by the SPU trunk water fund, which would be recovered by equivalent lateral watermain fees paid at the time of connection to the water system. Offering any extraordinary funding or connection timing options would need to be approved by the SPU Commission. The Commission is not being asked to approve any funding for this project at this time.

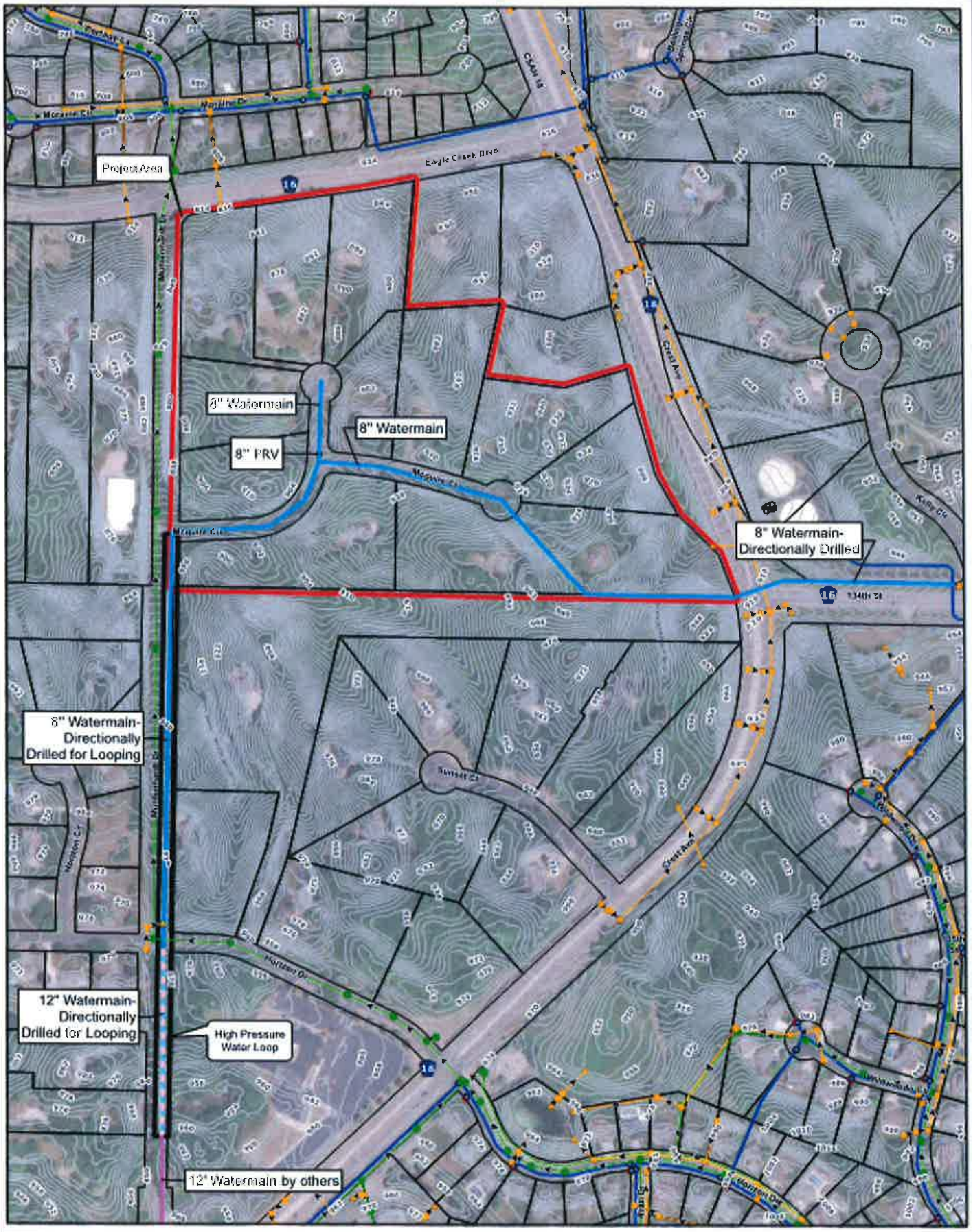
REQUESTED ACTION

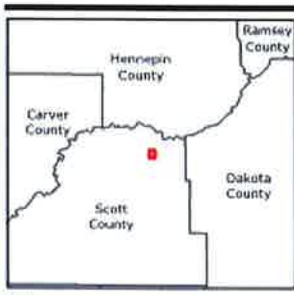
Because of the large lots and low-density residential nature of the properties to be served, the estimated costs per lot to construct a complete water system meeting all of the SPU Water Policy design criteria to serve this area is extremely high.

While waving the high pressure water loop makes the proposed project more economical for the twelve properties along McGuire Circle and Court, it is still unlikely to proceed due to high costs. However, City staff needs Commission guidance related to the minimum requirements necessary for a public water system to serve the project area for the project feasibility report.

Staff believes that the BASE WATER SERVICE system will provide adequate water service and fire flow to the project area. Staff will present on this agenda item to facilitate a Commission discussion related to the looping requirements and what, if any, waiver of design requirements the commission deems appropriate for serving the project area.

Staff is seeking a motion from the Commission with the desired lateral and looping requirements for the McGuire Circle, McGuire Court neighborhoods.





Legend

- Project Area
- High Pressure Water Loop
- 8" Proposed Watermain
- 12' Proposed Watermain
- 12" Watermain- Directionally Drilled for Looping
- Watermain
- Water Valves
- Hydrants
- Storm Sewer
- Storm Manholes
- Storm Inlets
- Storm Discharge Points
- Sanitary Gravity Main
- Sanitary Manholes
- Parcels
- Contour (2ft)

0 150 300 Feet

N

Stantec

City of Shakopee
Feasibility Study

Figure No.
1

Title
Watermain Alignments

EXHIBIT A

EXHIBIT C

OPINION OF PROBABLE COST
CITY OF SHAKOPEE
2025 CIP - WATERMAIN EXTENSION COSTS
193807258
FEASIBILITY STUDY
September 12, 2024

Stantec

NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL PRICE
HIGH PRESSURE LOOP ESTIMATE					
1	MOBILIZATION	LUMP SUM	1	$ 20,000.00	$ 20,000.00
2	TRAFFIC CONTROL	LUMP SUM	1	$ 15,000.00	$ 15,000.00
3	CLEARING & GRUBBING	LUMP SUM	0	$ 15,000.00	$ -
4	REMOVE AND PATCH BITUMINOUS PAVEMENT	SQ YD	300	$ 150.00	$ 45,000.00
5	EROSION AND SEDIMENT CONTROL	LUMP SUM	1	$ 3,000.00	$ 3,000.00
6	SITE RESTORATION	LUMP SUM	1	$ 5,000.00	$ 5,000.00
7	CONNECT TO EXISTING WATERMAIN	EACH	1	$ 7,500.00	$ 7,500.00
8	8" DUCTILE IRON WATERMAIN OPEN TRENCH	LIN FT	0	$ 75.00	$ -
9	8" HDPE WATERMAIN DIRECTIONALLY DRILLED	LIN FT	550	$ 125.00	$ 68,750.00
10	12" DUCTILE IRON WATERMAIN OPEN TRENCH	LIN FT	0	$ 110.00	$ -
11	12" HDPE WATERAMAIN DIRECTIONALLY DRILLED	LIN FT	600	$ 150.00	$ 90,000.00
12	24" STEEL CASING FOR JACKED CASING	LIN FT	0	$ 750.00	$ -
13	8" GATE VALVE AND FITTINGS	EACH	0	$ 4,750.00	$ -
14	12" GATE VALVE AND FITTINGS	EACH	2	$ 6,500.00	$ 13,000.00
15	16" GATE VALVE AND FITTINGS	EACH	0	$ 8,500.00	$ -
16	8" PRESSURE REDUCTION VALVE	EACH	0	$ 75,000.00	$ -
17	INSTALL HYDRANT AND VALVE	EACH	6	$ 7,500.00	$ 45,000.00
18	WATER SERVICES	EACH	0	$ 2,250.00	$ -
19	WATERMAIN FITTINGS	LUMP SUM	1	$ 50,000.00	$ 50,000.00
				SUBTOTAL BASE BID	$ 362,250.00

BASE BID	$ 362,250.00
[15%] CONTINGENCY	$ 54,337.50
[15%] ENGINEERING/ADMIN	$ 54,337.50
TOTAL CONSTRUCTION COSTS	$ 470,925.00

Exhibit B

OPINION OF PROBABLE COST
CITY OF SHAKOPEE
2025 CIP - WATERMAIN EXTENSION COSTS
193807258
FEASIBILITY STUDY
September 12, 2024

Stantec

NO.	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL PRICE
BASE WATER SERVICE ESTIMATE					
1	MOBILIZATION	LUMP SUM	1	$ 30,000.00	$ 30,000.00
2	TRAFFIC CONTROL	LUMP SUM	1	$ 15,000.00	$ 15,000.00
3	CLEARING & GRUBBING	LUMP SUM	1	$ 12,500.00	$ 12,500.00
4	REMOVE AND PATCH BITUMINOUS PAVEMENT	SQ YD	50	$ 150.00	$ 7,500.00
5	EROSION AND SEDIMENT CONTROL	LUMP SUM	1	$ 3,500.00	$ 3,500.00
6	SITE RESTORATION	LUMP SUM	1	$ 5,000.00	$ 5,000.00
7	CONNECT TO EXISTING WATERMAIN	EACH	2	$ 7,500.00	$ 15,000.00
8	8" DUCTILE IRON WATERMAIN OPEN TRENCH	LIN FT	1520	$ 75.00	$ 114,000.00
9	8" HDPE WATERMAIN DIRECTIONALLY DRILLED (1)	LIN FT	2560	$ 125.00	$ 320,000.00
10	12" DUCTILE IRON WATERMAIN OPEN TRENCH	LIN FT	0	$ 110.00	$ -
11	12" HDPE WATERAMAIN DIRECTIONALLY DRILLED	LIN FT	0	$ 150.00	$ -
12	24" STEEL CASING FOR JACKED CASING	LIN FT	110	$ 750.00	$ 82,500.00
13	8" GATE VALVE AND FITTINGS	EACH	4	$ 4,250.00	$ 17,000.00
14	12" GATE VALVE AND FITTINGS	EACH	0	$ 6,500.00	$ -
15	16" GATE VALVE AND FITTINGS	EACH	1	$ 8,500.00	$ 8,500.00
16	8" PRESSURE REDUCTION VALVE	EACH	1	$ 75,000.00	$ 75,000.00
17	INSTALL HYDRANT AND VALVE	EACH	5	$ 7,500.00	$ 37,500.00
18	WATER SERVICES	EACH	12	$ 2,250.00	$ 27,000.00
19	WATERMAIN FITTINGS	LUMP SUM	1	$ 30,000.00	$ 30,000.00
				SUBTOTAL BASE BID	$ 800,000.00

(1) Includes 800' of Watermain Along Mhulenhardt Drive

BASE BID	$ 800,000.00
[15%] CONTINGENCY	$ 120,000.00
[15%] ENGINEERING/ADMIN	$ 120,000.00
TOTAL CONSTRUCTION COSTS	$ 1,040,000.00

NUMBER OF BENEFITED PROPERTIES	12
CONSTRUCTION COSTS PER PROPERTY	$ 86,666.67
FEES AND CONNECTION COSTS PER PROPERTY (AVG LOT AREA 2.4 ACRES)	$ 23,500.00
TOTAL CONSTRUCTION COSTS	$ 110,178.67

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SHAKOPEE PUBLIC UTILITIES
MEMORANDUM

TO: Greg Drent, General Manager
Joseph Adams, Engineering Director

FROM: Ryan Halverson, Water Engineering Supervisor

SUBJECT: Tank 9 Reject All Bids and Rebid

DATE: October 7, 2024

ISSUE

Shakopee Public Utilities staff has received bids for the elevated storage Tank 9 project. The bids are higher than expected, and staff seeks Commission approval to reject all bids and rebid the project.

BACKGROUND

SPU has a project in the 5-year Capital Improvement Plan to construct a 0.5MG elevated storage Tank 9 in the 2-HES zone on the same site of Ground Storage Tank #7, which serves the 1-HES zone. SPU staff, along with engineering consultant Barr Engineering, has developed construction plans and specifications for the project. In accordance with Minnesota Statute Section 471.347 Uniform Municipal Contracting Law, bids were solicited and opened on September 30, 2024. Two bids were received and opened during the public bid opening and McQuire Iron, Inc., from Sioux Falls, SD was the apparent low bidder in the amount of $4,548,000.00. The other bid was submitted by Pheonix Fabricators & Erectors from Avon, IN in the amount of $5,256,261.00.

DISCUSSION

Since 2020, construction costs for infrastructure projects, including watermain and electric control components have seen significantly higher costs. Labor costs, steel and electrical control components are all subject to higher pricing and these industries still struggles with long lead times for procurement. The recent updated Barr Engineers' Estimate construction only cost for the project was $4,400,000. This estimated amount utilized the Contractor bid unit prices from the 2019 Tank 8 project and adjusted by 36% (2019 – 2024) construction inflation per the Mortenson construction cost index for projects located in the Minneapolis area.

Shakopee Public Utilities

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Project Budget:

Low Bid (Mequire Iron, Inc.)	$ 4,548,000
5% Construction Contingency	$ 200,000
City Building Permit Fee	$ 100,000
Engineering (SPU/Barr Engineering)	$ 390,000
Total Proposed Project Cost	$ 5,238,000

The 2024 CIP Budget for the Tank 9 project is $4,000,000. The total estimated project cost is $1,238,000 over the budgeted amount.

Several minor bid document clarifications were needed during the bidding process and an addendum was released late in the process. Contractors voiced concern and asked for additional time to submit bids, but to meet Commission meeting dates, the bid date only was adjusted from Thursday September 26, 2024 to Monday September 30, 2024. Additionally, staff believes that communications disruptions to the Verizon Wireless cellular network and damage to communications infrastructure in the southeast part of the country due to Hurricane Helene on the day of the bid may have in part created an unfavorable condition for bidders.

Rebidding the project is likely to result in more bid submittals and potentially more competitive bid prices. Delaying the initial start of the construction of the elevated storage tank will not impact the tower completion of its' completion, and will not impact SPU's ability to continue to provide adequate water supply in the 2-HES zone.

Lastly, the recently adopted 2024 Comprehensive Water Plan shows a larger 16-inch trunk water main need from Tank 9, heading east and eventually connecting to the future water treatment plant in the NES-Zone. These changes could be incorporated into a new bid, versus a change order to the existing project bid documents.

FUNDING

All of the cost associated with the engineering design, administration and construction of the proposed elevated storage Tank 9 project is proposed to be paid for by the Connection Fund. All costs over the CIP budgeted amount would be proposed to be paid for from the Connection Fund, which has a sufficient balance to cover the additional expense. The 2025 CIP will be updated to reflect the new estimated project cost.

REQUESTED ACTION

Based on the higher than expected bids, staff requests the Commission to motion to reject all bids for the Tank 9 project and rebid the project.

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7b

SHAKOPEE PUBLIC UTILITIES
MEMORANDUM

TO: Greg Drent, General Manager

FROM: Joseph D. Adams, Planning & Engineering Director

SUBJECT: ELECTRIC SYSTEM LONG RANGE PLANNING STUDY

DATE: October 3, 2024

The Utilities Electrical Consulting Engineer Kevin Favero of Leidos will present the attached report at the October 7th Commission meeting.

Draft Report

Long Range Planning Study

Shakopee Public Utilities

October 2, 2024

Draft Report

Long Range Planning Study

Shakopee Public Utilities

October 2, 2024

leidos

Table of Contents

List of Appendices

List of Tables

Leidos Engineering, LLC ("Leidos") has been retained by Shakopee Public Utilities (SPU) to prepare this Long Range Planning Study (the Study) to assist SPU with supplying reliable and cost-effective service to the electric customers in the SPU service territory. The Study includes a 10-year planning period through 2033 (the Study Period). This Report summarizes the analysis, findings, and recommendations of the Study.

Forecast Load Growth

The forecast for the Study Period includes nominal overall growth for the SPU feeders (at 1% to 3% annual growth rates except for DL-98 northwest of Canterbury Park with a 10% annual growth rate), short term known spot loads identified by SPU staff, and long term spot loads forecast by SPU and Leidos. The location of the forecast spot loads is shown on the map in **Appendix A**. The forecast is summarized as follows in Table ES-1.

Table ES-1
Forecast Non-coincident Feeder Load Growth

	Load (kW) [1]
2023 Aggregate	112,100
Overall 10-year nominal growth	18,800
Short term spot loads	14,700
Long term spot loads	49,700
2033 Aggregate	195,400
Cumulative 10-year annual compound growth rate	5.7%

[1] Aggregate non-coincident feeder load.

As shown in Table ES-1 above, the aggregate non-coincident peak feeder load is forecasted to grow at a cumulative annual compound growth rate of 5.7% from 112,100 kW[1] in 2023 to 195,400 kW in 2033.

Analysis Results

Proposed upgrades to enable the SPU electric system to serve peak loads for single contingency outages without facility overloads or low circuit voltage are shown in Table ES-2 below. The forecast load level (LL) and year when the upgrade is needed are shown. Since loads might not develop when forecasted, the load additions should be monitored over time and the in-service date should be adjusted to meet actual load increases.

[1] 1 kW = 1,000 watts

Table ES-2
Proposed Upgrades for SPU Electric System

Project Number	Project Description	Year in Service & LL	Estimated Cost ($2024)
P1	Convert SS-31 to 3-phase 1/0 AAC south of CR 14	2025 LL02	$63,000
P2	Switching to shift load from PL-71 to PL-77	2025 LL02	Not appl.
P3	Install civil work for East Shakopee Sub	2025 LL02	$587,000
P4	Design express circuits to Shakopee Sub, one from West Shakopee Sub (WS-06) and one from South Shakopee Sub (SS-35)	2025 LL02	$300,000
P5	Upgrade circuit along Highway 169 to 336 AAC to provide backbone tie between WS-02 and WS-11 and ability to transfer load	2026 LL03	$525,000
P6	Balance phase loading on DL-92	2026 LL03	Not appl.
P7	Install express circuits to Shakopee Sub, one from West Shakopee Sub (WS-06) and one from South Shakopee Sub (SS-35)	2026 LL03	$2,043,000
P8	Reconductor overhead conductor on PL-74 along CR 16 from 4/0 AAC to 336 kcmil ACC	2026 LL03	$192,000
P9	Install DL-91 to serve Canterbury Park and extend to tie to DL-98	2026 LL03	$527,000
P10	Install WS-03 to serve load west of CR 69	2027 LL04	$110,000
P11	Install aggregate 20,400 kVAR capacitor banks across the distribution system, as needed for voltage and power factor support	2027 LL04	$1,530,000
P12	Activate capacitor bank on SS-32 along CR 15 north of Highway 169	2027 LL04	Not appl.
P13	Install WS-04 south on CR 69 and east on 17th Avenue extended to tie to SS-32 and to serve SS-32 load	2027 LL04	$379,000
P14	Balance phase loading on PL-73	2027 LL04	Not appl.
P15	Install new East Shakopee Substation and two circuits to serve BL-22 and a portion of PL-73. Transfer PL-74 load to PL-73. Transfer all of BL-20 load to PL-74.	2027 LL04	$6,698,000
P16	Install SS-84 and transfer load from SS-31. Transfer load from PL-71 to SS-31	2028 LL05	$277,000
P17	Install new West Shakopee power transformer and switchgear	2028 LL05	$6,163,000
P18	Install WS-12 to serve load east of CR 69 and north of the bluff	2028 LL05	$174,000
P19	Install WS-13 to serve load west of CR 69	2029 LL06	$104,000

Conclusions

Based on the analysis described herein, the proposed upgrades shown above are projected to enable the SPU electric system to meet forecast peak load growth through 2033 for single contingency outages without facility overloads or low circuit voltage.

Additional details of the analyses, findings, and recommendations are discussed in Section 1 and Section 2 of this Report.

Assumptions and Considerations

The Study is based on the following assumptions and considerations.

- The historical peak load data for the SPU circuits are accurate
- The forecasted load growth (general load growth and spot loads) will occur as forecasted.
- The geographic information system (GIS) data and Windmil computer model of the SPU electric system are accurate with the upgrades discussed with SPU staff.
- The planning criteria described in Section 2 are used for the analysis.

General Basis of Study

In the preparation of this Study report, including the opinions contained herein, certain assumptions and considerations were made with respect to conditions that may occur in the future. The analysis was performed using the available data and assumptions contained herein. Certain computer software, as described herein, was used to analyze the SPU electric distribution facilities. While these considerations and assumptions are reasonable and reasonably attainable based on conditions known as of the date of this report, they are dependent on the accuracy of the data provided and future events. Actual conditions may differ from those assumed herein or from the assumptions provided by others and therefore, the actual results may vary from those estimated.

Section 1
INTRODUCTION & METHODOLOGY

1.1 Introduction

Leidos has completed the Study to forecast load growth and identify mitigations and upgrades to resolve planning criteria violations for future load levels in future years. The Study assists SPU in developing future capital plans that will allow SPU to continue to supply the electric load in the SPU service territory in a reliable and cost-effective approach. By using this approach, interim changes and system upgrades will be compatible with capacity level needs as system load changes occur.

1.2 Background

SPU delivers electric power and energy to the retail electric customers in the SPU service territory. The SPU electric substations receive power from Minnesota Municipal Power Agency over the 69 kV[2] and 115 kV Xcel Energy transmission systems.

Electric power is delivered from the transmission systems over the following substations that step down the transmission voltage to 12.5 kV or 13.8 kV distribution voltage:

- Shakopee Substation in the northwest corner of the service territory (SH circuits)
- West Shakopee Substation in the western portion of the service territory (WS circuits)
- South Shakopee Substation in the southern portion of the service territory (SS circuits)
- Dean Lake Substation in the center of the service territory (DL circuits)
- Pike Lake Substation in the southeast portion of the service territory (PL circuits)
- Blue Lake Substation (owned by Xcel Energy) in the northeast corner of the service territory (BL circuits)

Power is delivered to retail customers over 37 distribution circuits that are served by the above electric substations.

1.3 Load Forecast

Leidos developed a load forecast by circuit over the Study Period as a basis for identifying the upgrades needed. Nominal growth rates were assigned to each circuit to account for load growth due to the potential for customers to add loads to existing buildings, appliances, and non-traditional electrical uses such as charging electric vehicles. The potential installation of solar photovoltaic (PV) systems (which would

[2] 1 kV = 1,000 volts

result in a net reduction in load flow seen on the circuit) was not specifically taken into consideration since the peak PV output occurs at noon (when the solar radiation is at a maximum) and PV output drops significantly as solar radiation decreases by early evening when the peak load has historically occurred.

SPU staff identified known short term spot loads. SPU staff and Leidos forecast long term spot loads based on open land areas and potential development over the Study Period. The spot loads are summarized in Table 1-1 below. To forecast spot loads, information on land use and development densities described in the following documents was used:

- City of Shakopee 2040 Comprehensive Plan (Envision Shakopee)
- Southern Shakopee Alternative Urban Areawide Review
- Jackson Township Development Area Alternative Urban Areawide Review

The load forecast by circuit is summarized in the following table.

Table 1-1
Non-coincident Load Forecast by Circuit over the Study Period (MW)

Circuit	Base Load 2023	10-Year Nominal Growth	Known Spot Loads	Forecast Spot Loads	Total 10-Year Growth	Forecast 2033 Load LL10
Blue Lake						
BL-20	2.6	0.3			0.3	2.8
BL-22	4.3	0.9		1.0	1.9	6.2
Shakopee						
SH-07	4.3	0.4			0.4	4.7
SH-08	5.6	0.6		0.5	1.1	6.7
SH-09	4.8	0.5	0.3		0.8	5.6
SH-10	3.6	0.4			0.4	4.0
South Shakopee 1						
SS-31	1.8	0.6	0.9	0.9	2.4	4.2
SS-32	4.5	1.0		2.4	3.4	7.8
SS-33	4.8	0.5			0.5	5.3
SS-34	6.1	0.6			0.6	6.7
South Shakopee 2						
SS-81	4.4	0.5			0.5	4.9
SS-82	3.0	0.3			0.3	3.3
SS-83	4.0	0.9	2.7	1.7	5.3	9.3
Pike Lake						
PL-71	5.6	1.2	0.8	6.1	8.1	13.7
PL-72	0.0	0.0		0.0	0.0	0.0

Circuit	Base Load 2023	10-Year Nominal Growth	Known Spot Loads	Forecast Spot Loads	Total 10-Year Growth	Forecast 2033 Load LL10
PL-73	1.5	0.3		4.0	4.3	5.8
PL-74	2.2	0.2	0.7		0.9	3.1
PL-75	3.2	0.7		1.0	1.7	4.9
PL-77	1.0	0.2		0.4	0.6	1.6
Dean Lake 1						
DL-41	5.4	0.1	3.0	2.5	5.6	11.0
DL-42	0.1	0.0	3.5		3.5	3.6
DL-43	3.9	0.8			0.8	4.7
DL-44	1.3	0.3		0.5	0.8	2.0
DL-46	1.5	0.3	0.7	1.5	2.5	3.9
DL-47	1.4	0.1	0.2		0.3	1.7
DL-48	3.8	0.4		1.6	2.0	5.7
Dean Lake 2						
DL-51	3.0	0.3			0.3	3.3
DL-52	2.1	0.2		0.5	0.7	2.8
DL-55	3.6	0.8	0.0		0.8	4.4
DL-56	3.8	0.8		0.5	1.3	5.1
DL-57	1.6	0.2		1.0	1.2	2.8
DL-58	3.9	0.9		2.5	3.4	7.3
Dean Lake 3						
DL-92	4.2	0.9	1.3	1.3	3.5	7.7
DL-96	3.9	0.9			0.9	4.8
DL-98	1.7	1.6	0.5	0.0	2.1	3.8
West Shakopee						
WS-01	0.0	0.0		0.8	0.8	0.8
WS-02	0.0	0.0	0.3	19.0	19.3	19.3
Total System	112.1	18.8	14.7	49.7	83.3	195.4

As shown in the above table, aggregate non-coincident feeder peak load is forecast to increase 83.3 MW from 112.1 MW in 2023 to 195.4 MW in 2033 which is a 5.7% compound annual growth rate.

1.4 Spot Load Forecast

The short term known spot loads and the long term forecast spot loads are listed in Table 1-2 below and are shown on the map in **Appendix A**.

Table 1-2
Spot Load Forecast

Spot Load	Connected kVA	Peak Load (kW)	Estimated In-service Year	Existing Circuit
Short Term				
Inland Devel. Warehouse Dean Lakes Dev.	750	150	2024	DL-46
Inland Devel. Warehouse Dean Lakes Dev.	750	150	2024	DL-47
Emblem Apartments N. of 17th Ave.	1,275	1,275	2024	DL-92
River Valley Bus. Park Warehouse W. of CR 69	2,500	300	2024	WS-02
GN (Shutterfly Bldg.)	500	500	2025	DL-46
Whispering Waters Residential S. of CR 16	750	670	2025	PL-74
Arbor Bluff Residential S. of Valley View	800	388	2025	PL-71
Arbor Bluff Residential S. of Valley View		413	2026	PL-71
High View Residential S. of CR 78	2,700	1,470	2025	SS-83
High View Residential S. of CR 78		238	2026	SS-83
High View Residential S. of CR 78		1,000	2027	SS-83
Canterbury Park Amphitheater	3,000	3,000	2025	DL-41
Canterbury 9th	500	500	2025	DL-98
CDA Office & Apartments 6th Ave.	300	300	2025	SH-09
Dockendorf SMSC CR 17	900	900	2026	SS-31
Eagle Crest Resid. & Comm. W. of CR 83	3,500	1,167	2026	DL-42
Eagle Crest Resid. & Comm. W. of CR 83		1,167	2027	DL-42
Eagle Crest Resid. & Comm. W. of CR 83		1,167	2028	Dl-42
Total Short Term		14,753		DL-42
Long Term				
Commercial on 12th Ave.	500	500	2025	DL-44
Residential / Commercial along CR 18	1,000	1,000	2026	PL-73
Trio Commercial / Apartments CR 18	1,000	1,000	2026	PL-75
FedEx EV Charging 12th Ave.	800	800	2026	DL-48
Data Centers Coneflower Dr.	2,500	2,500	2026	DL-58
1000 Valley Park Area	500	500	2026	DL-56
Data Card Area	1,000	1,000	2026	DL-57
Residential N. of 17th Ave.	300	300	2026	DL-92
Commercial Upgrade 4th Ave Area	500	500	2026	SH-08
SMSC Residential	400	400	2026	PL-77
SMSC Healing Center	500	500	2026	PL-73
Commercial West of CR 69	5,000	5,000	2026	WS-02
Commercial West of CR 69	5,000	5,000	2027	WS-02
Residential along CR 17	900	900	2027	SS-31

Spot Load	Connected kVA	Peak Load (kW)	Estimated In-service Year	Existing Circuit
Gateway Townhomes N. of Hwy 169	200	200	2027	WS-01
Commercial Deans Lake Devel.	1,500	1,500	2027	DL-46
Commercial N. of 17th Avenue	1,000	1,000	2027	DL-92
Commercial Stagecoach Road	1,000	1,000	2027	PL-73
Residential along Eagle Creek Blvd.	500	500	2027	DL-52
Residential west of CR 15	800	800	2027	SS-32
Commercial West of CR 69	5,000	5,000	2028	WS-02
Residential N. of Hwy 169	100	100	2028	WS-01
Commercial along Hwy 101	1,000	1,000	2028	BL-22
Residential along CR 15	1,700	1,700	2028	SS-83
Commercial in Canterbury Park	2,500	2,500	2028	DL-41
Residential South of Valley View	2,300	2,300	2028	PL-71
Residential South of Valley View	2,300	2,300	2029	PL-71
Residential West of CR 15	800	800	2029	SS-32
FedEx EV Charging 12th Ave	800	800	2029	DL-48
Commercial Stagecoach Road	1,000	1,000	2029	PL-73
SMSC Residential	500	500	2029	PL-73
Commercial along Hwy 169	2,000	2,000	2029	WS-02
Cherne N. of Hwy 169	500	500	2030	WS-01
Residential West of CR 15	800	800	2031	SS-32
Commercial along Hwy 169	2,000	2,000	2031	WS-02
Water Treatment Facility on CR 83	1,500	1,500	2033	PL-71
Total Long Term		49,700		
Total Short Term and Long Term		62,453		

As shown in the above table, the total estimated short term aggregate spot load is 14,753 kW and the total estimated long term aggregate spot load is 49,700 kW. Total estimated aggregate spot load is 62,453 (62.5 MW).

1.5 Model of Electric System and Analyses

SPU provided a copy of the geographic information system (GIS) data which describes the SPU electric system and a copy of the Milsoft Integrated Solutions Windmil model of the electric system. The Windmil computer program is used to perform load flow and voltage drop analysis on the SPU electric systems by allocating peak load data for each circuit based on connected distribution transformer capacity in kVA.

The overall load growth and spot loads by circuit are added to the base year peak load levels to prepare a Windmil model for each year of the Study Period. The Windmil model is then used to identify overloaded facilities and low voltage on the SPU circuits.

System upgrades are then identified to mitigate violations of the planning criteria for overloaded facilities and low voltages. Mitigation approaches used include:

- Balance loading by phase to reduce voltage drop and energy losses (it is recommended that SPU balance loading by phase for all circuits)
- Install capacitor banks to reduce voltage drop and energy losses (it is a planning criterion that SPU install capacitor banks on all circuits as needed to maintain a 97% or higher power factor at peak load)
- Install voltage regulators to reduce voltage drop
- Increase conductor size to reduce voltage drop and energy losses
- Increase conductor size to relieve overloaded circuits
- Install new circuits to reduce loading on existing circuits
- Install new substation power transformers, switchgear buildings, and exit circuits to reduce voltage drop and loading on existing circuits

1.6 Planning Criteria

1.6.1 Description of Planning Criteria

The planning criteria used for this Study include the following:

- With all facilities in service, loading on all facilities does not exceed the normal rating of the facility. Target loading of any circuit is 6,000 kVA to minimize energy losses and enable the restoration of service for single outage contingencies.
- With all facilities in service, voltage on the primary circuits (12.5 kV and 13.8 KV) does not drop below 118 volts on a 120-volt basis.
- With single contingency outages, loading on all facilities does not exceed the emergency rating of the facility. Circuit switching is identified to try to keep loading below the normal rating of facilities.
- With single contingency outages, voltage on the primary circuits (12.5 kV and 13.8 kV) does not drop below 114 volts on a 120-volt basis.
- Maximum voltage on the primary bus at each substation is 126 volts on a 120-V basis. SPU typically sets the primary bus voltage at each substation at 123 volts on a 120-volt basis.
- Total aggregate peak load on BL-20 and BL-22 is 8.3 MW per contract with Xcel Energy. When the new East Shakopee Substation is installed, all BL-20 and BL-22 loads will be switched to other SPU circuits.
- Power factor for each circuit will be adjusted to 97% or above by installing capacitor banks.

Section 2
DISTRIBUTION ANALYSIS RESULTS

2.1 Proposed Facility Upgrades

Based on the approach described in Section 1, the following summarizes the findings from the distribution system analysis. Criteria violations and mitigations have been identified and described below for the annual load levels both with and without considering contingency outages.

The consideration of contingency outages requires some of the mitigations to be advanced to earlier load level years and requires some additional mitigations, both as described below.

2.1.1 Planning Year 2024 LL01

For Planning Year 2024, no criteria violations have been identified:

2.1.2 Planning Year 2025 LL02

For Planning Year 2025, the following criteria violations have been identified:

SS-31

- Overload on a section of SS-31 due to the addition of the SMSC Dockendorf load on SS-31 along CR 17 south of CR 14.

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P1 Convert SS-31 south of CR 14 to 3-phase and upgrade the conductor to 1/0 AAC.

PL-71

- Low voltage on PL-71 downstream of section UGPRI-4381 due to existing load levels.

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P2 Shift load from PL-71 to PL-77 by closing switch 956 and opening switch 503.

East Shakopee Substation Preparation

- P3 Perform civil work at East Shakopee Substation site to prepare for future construction.

Shakopee Substation

- Shakopee Substation has one 69 kV source. Outage of the 69 kV source results in outage of the substation.

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P4 Design express circuits from West Shakopee Substation and East Shakopee Substation for emergency use. Install in the following Planning Year and LL.

2.1.3 Planning Year 2026 LL03

For Planning Year 2026, the following criteria violation has been identified.

WS-02

- Loads along Highway 169 do not have a backup source.

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P5 Replace all 4/0 AAC conductor along Highway 169 from WS-02 to WS-01 to provide a backbone tie between the two circuits and allow load to be shifted. Install new 3-phase 600A switch between circuit WS-01 and WS-02. Install 3-way padmount switch at the north end of WS-01 along Highway 169.

DL-92

- Low voltage on DL-92 downstream of section UGPRI-3805 due to existing load levels and circuit phase unbalance.

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P6 Shift load from Phase A to Phase B at Section UG50712 to balance the circuit load

Shakopee Substation

- Shakopee Substation has one 69 kV source. Outage of the 69 kV source results in outage of the substation.

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P7 Install express circuits from West Shakopee Substation and East Shakopee Substation for emergency use.

PL-74

- Portions of PL-74 are 4/0 AAC overhead conductor which limit the ability of the circuit to provide backup capacity to PL-73.

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P8 Reconductor overhead conductors on PL-74 along CR 16 from 4/0 AAC to 336 kcmil AAC.

DL-98

- Overload of DL-98 serving DL-41 load for contingency outage of DL-41 with 2.5 MW of future commercial spot load development.

To resolve the above planning criteria violation and to facilitate installation of facilities during the Canterbury Park construction, the following facility upgrades are proposed:

- P9 Install new DL-91 circuit and transfer Canterbury Park load from DL-41 to DL-91 and install tie to DL-98 for backup.

2.1.4 Planning Year 2027 LL04

For Planning Year 2027, the following criteria violation has been identified.

WS-02

- Overloading circuit WS-02 due to spot load additions west of CR 69. One 5 MW spot load has been forecasted for 2026 and a second 5 MW spot load has been forecasted for 2027.

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P10 Install new feeder WS-03 to run south from West Shakopee Substation approximately 0.2 miles and west to serve the second 5 MW spot load.

Multiple Circuits with Low Power Factor

- Multiple circuits have power factor below the 97% planning criteria.

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P11 Install 20,400 kVAR of capacitor banks across the distribution system, as needed for power factor and voltage support.

SS-32

- Low voltage downstream of line sections UGPRI-66325 and UGPRI-51880.

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P12 Activate existing capacitor bank along CR 15 north of Highway 169.
- P13 Install new circuit WS-04 south from Substation along CR 69 and east along extended 17th Avenue to serve new residential load along 17th Avenue and tie to circuit SS-32. Transfer load from SS-32 to WS-04.

PL-73

- Low voltage downstream of sections UGPRI-2956.

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P14 Balance load by phase by transferring load from B phase to A phase at line taps OHPRI-3296 and OHPRI-3299.

Multiple Circuits

- Low voltage and overloads for multiple circuits for outage of Pike Lake switchgear building and serving all Pike Lake circuits from other substation circuit ties.

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P15 Install new East Shakopee Substation in the southwest corner of the intersection of Hanson Avenue and Maras Street. Install two new circuits to Stagecoach Road to intercept PL-73 and serve one circuit north and one circuit south. Serve BL-22 and a portion of PL-73 load with East Shakopee Substation circuits and rebalance loading by closing switches 937 on Highway 101, 436 in Southbridge, and 550 on CR 16 and opening switches 858 on CR 16 and 579 on CR 18. Transfer load from PL-74 to PL-73 and transfer all of BL-20 load to PL-74.

2.1.5 Planning Year 2028 LL05

For Planning Year 2028, the following criteria violations have been identified.

PL-71

- Low voltage at section OHPRI-260 and downstream

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P16 Install new circuit SS-84 from South Shakopee Substation east to currently open switch 821 on CR 17. Transfer load from SS-31 to SS-84 by closing switch 821 and opening switch 889 at CR 17 and CR 78. Transfer load from PL-71 to SS-31 by closing switch 903 on Valley View Drive and opening switch 918 on Valley View Drive.

WS-02

- Overloading circuit WS-02 due to spot load addition east of CR 69. One 5 MW spot load east of CR 69 has been forecasted for 2028.

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P17 Install new power transformer and switchgear in West Shakopee Substation. New circuits to be series WS-11 through WS-15.
- P18 Install new feeder WS-12 to run south from West Shakopee Substation approximately 0.2 miles and east to serve the new 5 MW spot load east of CR 69 and north of the bluff.
- Reconnect circuit WS-01 to new switchgear and rename as WS-11.

2.1.6 Planning Year 2029 LL06

WS-02

- Overload of circuit due to new forecasted 2 MW spot load along Highway 169.

To resolve the above planning criteria violation, the following facility upgrades are proposed:

- P19 Install new circuit WS-13 south and connect it to a new 3-way switch installed in circuit WS-02 west of CR 69 to allow WS-13 to serve the portion of WS-02 west of CR 69 and to allow WS-02 to continue to serve south along CR 69, west along CR 78, and along Highway 169.

2.1.7 Planning Year 2030 LL07

For Planning Year 2030, no criteria violations have been identified.

2.1.8 Planning Year 2031 LL08

For Planning Year 2031, no criteria violations have been identified.

2.1.9 Planning Year 2032 LL09

For Planning Year 2032, no criteria violations have been identified.

2.1.10 Planning Year 2033 LL10

For Planning Year 2033, no criteria violations have been identified.

The results of the analyses described above in Section 2.1 are summarized below in Section 2.2.

2.2 Summary of Proposed Facility Upgrades

Based on the analyses described above in Section 2.1, the facility upgrades proposed to resolve planning criteria violations are summarized in the following table and the projects requiring capital expenditures (except for the capacitor banks) are shown on the map in **Appendix B**.

Table 2-1
Summary of Proposed Facility Upgrades to Mitigate Planning Criteria Violations

Project Number	Project Description	Year in Service & LL	Estimated Cost ($2024)
P1	Convert SS-31 to 3-phase 1/0 AAC south of CR 14	2025 LL02	$63,000
P2	Switching to shift load from PL-71 to PL-77	2025 LL02	Not appl.
P3	Install civil work for East Shakopee Sub	2025 LL02	$587,000
P4	Design express circuits to Shakopee Sub, one from West Shakopee Sub (WS-06) and one from South Shakopee Sub (SS-35)	2025 LL02	$300,000
P5	Upgrade circuit along Highway 169 to 336 AAC to provide backbone tie between WS-02 and WS-11 and ability to transfer load	2026 LL03	$525,000
P6	Balance phase loading on DL-92	2026 LL03	Not appl.
P7	Install express circuits to Shakopee Sub, one from West Shakopee Sub (WS-06) and one from South Shakopee Sub (SS-35)	2026 LL03	$2,043,000
P8	Reconductor overhead conductor on PL-74 along CR 16 from 4/0 AAC to 336 kcmil ACC	2026 LL03	$192,000
P9	Install DL-91 to serve Canterbury Park and extend to tie to DL-98	2026 LL03	$527,000
P10	Install WS-03 to serve load west of CR 69	2027 LL04	$110,000
P11	Install aggregate 20,400 kVAR capacitor banks across the distribution system, as needed for voltage and power factor support	2027 LL04	$1,530,000
P12	Activate capacitor bank on SS-32 along CR 15 north of Highway 169	2027 LL04	Not appl.
P13	Install WS-04 south on CR 69 and east on 17th Avenue extended to tie to SS-32 and to serve SS-32 load	2027 LL04	$379,000
P14	Balance phase loading on PL-73	2027 LL04	Not appl.
P15	Install new East Shakopee Substation and two circuits to serve BL-22 and a portion of PL-73. Transfer PL-74 load to PL-73. Transfer all of BL-20 load to PL-74.	2027 LL04	$6,698,000
P16	Install SS-84 and transfer load from SS-31. Transfer load from PL-71 to SS-31	2028 LL05	$277,000
P17	Install new West Shakopee power transformer and switchgear	2028 LL05	$6,163,000
P18	Install WS-12 to serve load east of CR 69 and north of the bluff	2028 LL05	$174,000
P19	Install WS-13 to serve load west of CR 69	2029 LL06	$104,000

Circuit loading in planning year 2033 (LL10) is summarized in the following table.

Table 2-2
Forecasted Circuit Loading in 2033 (LL10)

Substation and Circuit	Forecasted Peak Load (MW)	Rating (MW)	Loading as Percent of Rating
Blue Lake			
BL-20	0.0	9.4	0%
BL-22	0.0	9.4	0%
Shakopee			
SH-07	4.7	8.5	55%
SH-08	6.6	8.5	78%
SH-09	5.6	8.5	66%
SH-10	5.6	8.5	66%
South Shakopee 1			
SS-31	4.9	8.5	57%
SS-32	5.4	8.5	64%
SS-33	5.3	8.5	63%
SS-34	6.7	8.5	79%
South Shakopee 2			
SS-81	4.9	8.5	58%
SS-82	3.3	8.5	39%
SS-83	4.9	8.5	58%
SS-84	3.4	8.5	40%
Pike Lake			
PL-71	6.2	9.4	66%
PL-72	0.0	9.4	0%
PL-73	4.4	9.4	46%
PL-74	4.3	9.4	45%
PL-75	6.0	9.4	64%
PL-77	5.2	9.4	56%
Dean Lake 1			
DL-41	1.3	9.4	14%
DL-42	3.7	9.4	39%
DL-43	4.7	9.4	50%
DL-44	2.0	9.4	22%
DL-46	5.2	9.4	56%
DL-47	1.7	9.4	18%
DL-48	5.8	9.4	61%

Substation and Circuit	Forecasted Peak Load (MW)	Rating (MW)	Loading as Percent of Rating
Dean Lake 2			
DL-51	3.3	9.4	35%
DL-52	2.8	9.4	30%
DL-55	4.4	9.4	46%
DL-56	5.1	9.4	54%
DL-57	2.8	9.4	29%
DL-58	6.1	9.4	64%
Dean Lake 3			
DL-91	6.0	9.4	64%
DL-92	7.0	9.4	74%
DL-96	4.7	9.4	50%
DL-98	6.6	9.4	70%
West Shakopee 1			
WS-02	2.8	8.5	32%
WS-03	5.0	8.5	59%
WS-04	2.4	8.5	28%
West Shakopee 2			
WS-11	5.1	8.5	60%
WS-12	5.0	8.5	59%
WS-13	6.7	8.5	79%
East Shakopee 1			
ES-01	5.7	9.4	60%
ES-02	2.6	9.4	27%
Total System	195.8		

As shown in the above table, the circuits with the highest forecasted load as a percentage of rating in 2033 (LL10) are SS-34 and WS-13 which are loaded to 79% of circuit rating.

Appendix A
One Line Diagram with Forecasted Spot Loads

REVISION	DATE	APPROVED BY	REVISION	DATE	APPROVED BY
10	12–21–20	BJC	1	06–09–14	MTA
11	09–23–21	BJC	2	07–29–14	MTA
12	07–11–22	BJC	3	10–16–14	MTA
13	09–26–22	BJC	4	01–06–15	MTA
14	12–12–22	BJC	5	10–24–16	GLD
15	07–16–24		6	05–05–17	GLD
16			7	02–05–18	GLD
17			8	01–14–18	GLD
18			9	12–09–19	GLD

TITLE

SYSTEM ONE LINE DIAGRAM MAP

SHAKOPEE PUBLIC UTILITIES
SHAKOPEE, MN.

DRAWN BY JTB	DATE 12–19–02	W/O
APPROVED BY MTA	DATE 01–22–01	
CHECKED BY	DATE	

Appendix B
One Line Diagram Showing Proposed Facility Upgrades

Appendix B
CARVER CO.
SCOTT CO.
HENNEPIN CO.
HENNEPIN COUNTY
SCOTT COUNTY
Minnesota River
Blue Lake
Fisher Lake
Rice Lake
Dean Lake
Pike Lake
O'Dowd Lake
Thole Lake
Schneider Lake
Howard Lake
SHAKOPEE SUBSTATION 945 1ST AVE W 69 KV – 12.47 KV
WEST SHAKOPEE SUBSTATION 2022 COLBURN DR W 115 KV – 12.47 KV
SOUTH SHAKOPEE SUBSTATION 13590 TOWNLINE AVE 115 KV – 12.47 KV
DEAN LAKE SUBSTATION 3755 EAGLE CREEK BLVD 115 KV – 13.8 KV
BLUE LAKE SUBSTATION 6896 HWY 101 115 KV – 13.8 KV
PIKE LAKE SUBSTATION 13560 EAGLE CREEK AVE NE 115 KV – 13.8 KV
EAST SHAKOPEE SUBSTATION
DETAIL A
DETAIL B
DETAIL C
DETAIL D
DETAIL E
DETAIL F
P4 & P7: Install express circuit from WS-06 to Shakopee Sub for emergency backup.
WS-01 to be reconnected to WS-11 when second power transformer and switchgear are installed.
P10: Install WS-03 to serve load west of CR 69
P19: Install WS-13 to serve load west of CR 69
P5: Upgrade circuit along Highway 169 to 336 AAC to provide backbone tie between WS-02 and WS-01 (to be reconnected to WS-11 in the future) and to provide the ability to transfer load
P18: Install WS-12 to serve load west of CR 69 and north of the bluff
P17: Install new West Shakopee Power Transformer and Switchgear
P4 & P7: Install express circuit from SS-35 to Shakopee Sub for emergency backup.
P13: Install WS-04 south on CR 69 and east on 17th Avenue extended to tie to SS-32 and to serve SS-32 load
P16: Install SS-84 and transfer load from SS-31. Transfer load from PL-71 to SS-31
P9: Install new DL-91 to serve Canterbury Park load and install tie to DL-98.
P1: Convert SS-31 to 3-phase 1/0 AAC south of CR 14
P8: Reconductor overhead line from 4/0 ACC to 336 kcmil AAC.
P3 & P15: Install new East Shakopee Substation and two circuits to serve all of BL-22 load and a portion of PL-73. Transfer PL-74 load to PL-73. Transfer all of BL-20 load to PL-74.
LEGEND
POLE/RISER
N.O. NORMALLY OPEN SWITCHING DEVICE
(SWITCH IS NORMALLY CLOSED UNLESS INDICATED)
SUBSTATION CIRCUIT BREAKER
VACUUM FAULT INTERRUPTER
THREE PHASE GANG SWITCH
SINGLE PHASE SWITCH
FUSE
LINE/CABLE CROSSING–NO CONNECTION
LINE/CABLE CROSSING WITH CONNECTION
UNDERGROUND CABLE
OVERHEAD LINE
FEED THRU CABINET
PAD MOUNT SWITCH RVAC 11
PAD MOUNT SWITCH RVAC 9
PAD MOUNT SWITCH VFI
VOLTAGE REGULATOR
SINGLE PHASE RECLOSER
THREE PHASE RECLOSER
FUTURE CIRCUIT
N
0' 1600' 3200'
(IN FEET)
SCALE: 1 INCH = 1600 FT.
REVISION DATE | APPROVED BY | REVISION DATE | APPROVED BY
10 12-21-20 BJC | 1 06-09-14 MTA
11 09-23-21 BJC | 2 07-29-14 MTA
12 07-11-22 BJC | 3 10-16-14 MTA
13 09-26-22 BJC | 4 01-06-15 MTA
14 12-12-22 BJC | 5 10-24-16 GLD
15 07-16-24 | 6 05-05-17 GLD
16 | 7 02-05-18 GLD
17 | 8 01-14-18 GLD
18 | 9 12-09-19 GLD
TITLE
SYSTEM ONE LINE DIAGRAM MAP
SHAKOPEE PUBLIC UTILITIES
SHAKOPEE, MN.
DRAWN BY JTB DATE 12-19-02 W/O
APPROVED BY MTA DATE 01-22-01
CHECKED BY DATE

8b

Shakopee Public Utilities

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Shakopee, Minnesota 55379
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www.shakopeeutilities.com

DATE: October 3, 2024

TO: Greg Drent, General Manager

FROM: Kelley Willemssen, Director of Finance & Administration

SUBJECT: Dave Berg Consulting, LLC

Dave Berg, Principal, from Dave Berg Consulting, LLC will be at the October 7th commission meeting to discuss preliminary results from his 2024 electric and water rate study.

Action:
Provide staff with direction on 2025 budget assumptions based on Dave Berg's results.

RP3