Resurrecting a Unidirectional Flushing Program: Getting the Program Up and Running

May 4, 2017
PNWS-AWWA Section Conference
Kennewick, WA

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Outline

- Why the need to flush in West Seattle?
- Unidirectional Flushing (UDF) Defined
- UDF Program Development
- Results of West Seattle 498 Zone Flushing Project
- SPU Participates in WRF Project #4653 Ensuring Flushing is a Corrective Action Under RTCR
- Where does SPU go from here?

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West Seattle Aesthetics Issues

- High number of customer complaints from West Seattle for discolored water early 2016. Why?
- Seattle Wells on July through November 2015
- Local reservoir down for earthquake retrofit, flow patterns change in large pressure zones
- Two incidents of errant hydrant use caused discolored water with strong, negative customer reaction
- Predominantly cast iron pipe, some more than 100 yrs old
- No comprehensive flushing conducted in area in last 15 years

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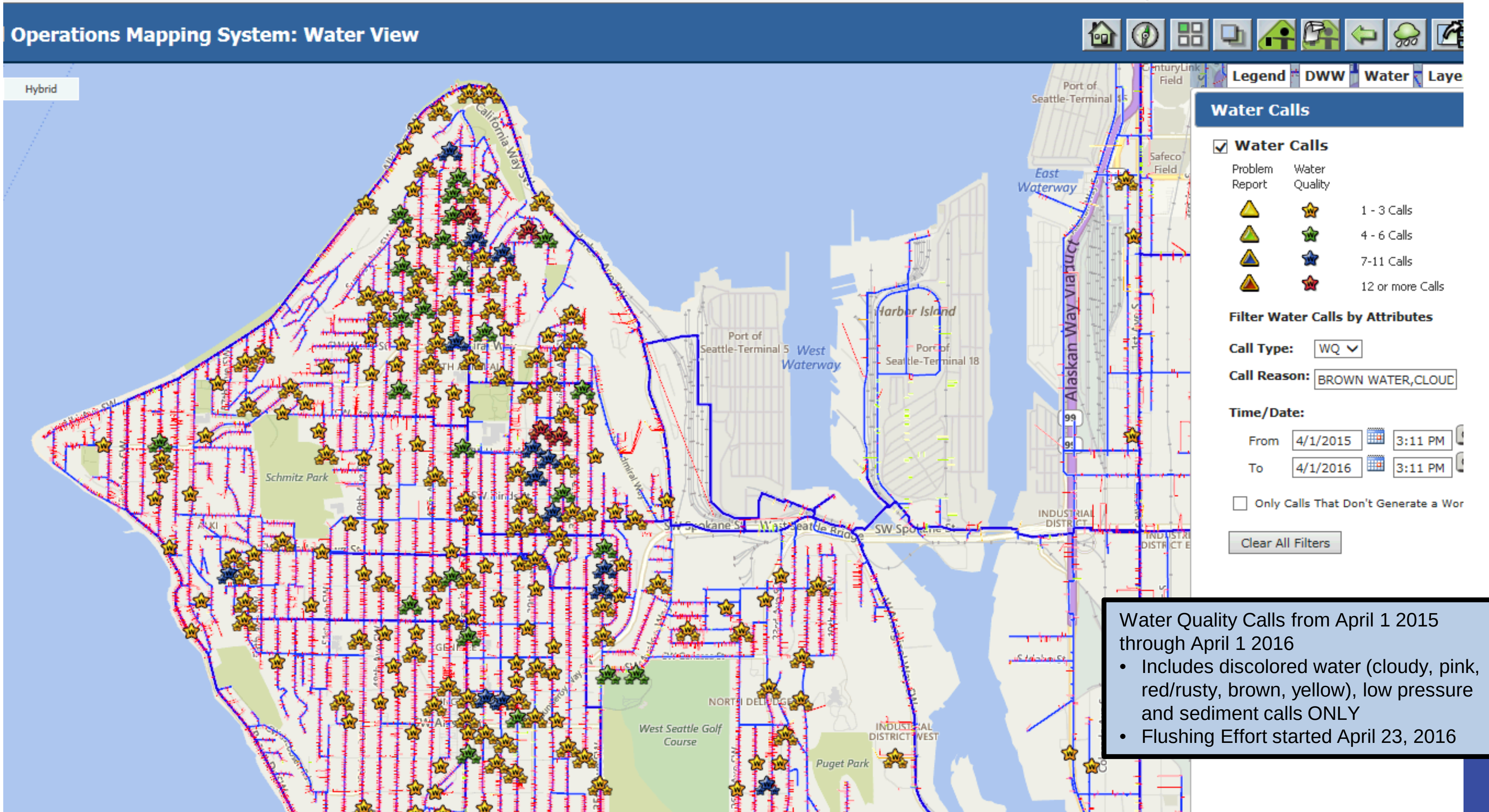
West Seattle Customer Calls



•FOMS system tracking WQ calls between April 1 2015 to April 1 2016

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WEST SEATTLE BLOG

NEWS 24/7

Here's who gets flushed first in West S water battle

APRIL 8, 2016 4:05 PM | 10 COMMENTS | UTILITIES | WEST SEATTLE I

Attack plan for brown water: Seattle Public Utilities plans large-scale West Seattle flush

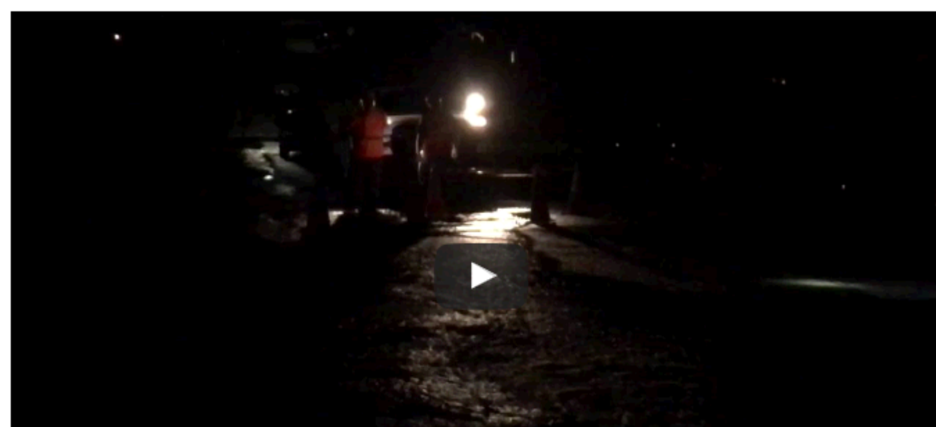
MARCH 31, 2016 12:34 PM | 11 COMMENTS | UTILITIES | WEST SEATTLE NEWS

FLUSH UPDATE: Night 3 tonight as Seattle Public Utilities works to clear WS water

APRIL 19, 2016 3:33 PM | 8 COMMENTS | UTILITIES | WEST SEATTLE NEWS

The Big West Seattle Flush, Week 4: The battle against brown water and what you need to know as it continues

MAY 11, 2016 11:28 AM | 9 COMMENTS | UTILITIES | WEST SEATTLE NEWS



Take Action!

- Media attention from local blog after upticks in customer complaints
- SPU Director gives the go ahead to resurrect flushing program ASAP under emergency funding
- Assemble team – engineers, crews, operations, GIS, laboratory expertise to get program up and running

Existing Flushing Program at SPU

- SPU does conduct spot flushing for WQ complaints or low chlorine
- No current conventional or UDF flushing program
- Partial UDF flushing sequence started in 2012 for Admiral District (498 Zone) in West Seattle – but no maps showing loops/sequence

What is UDF?

- Controlled flushing of system in segments at high velocity, proceeding in sequential order through the distribution system, always using clean water to flush the segment/loop
- Clean water interface (CWI) can be your source (working from source out into system), or a tank or a large diameter main
- Close valves to maintain flow in one direction through loop (or segment)
- Target high velocity (~5 fps) to scour mains

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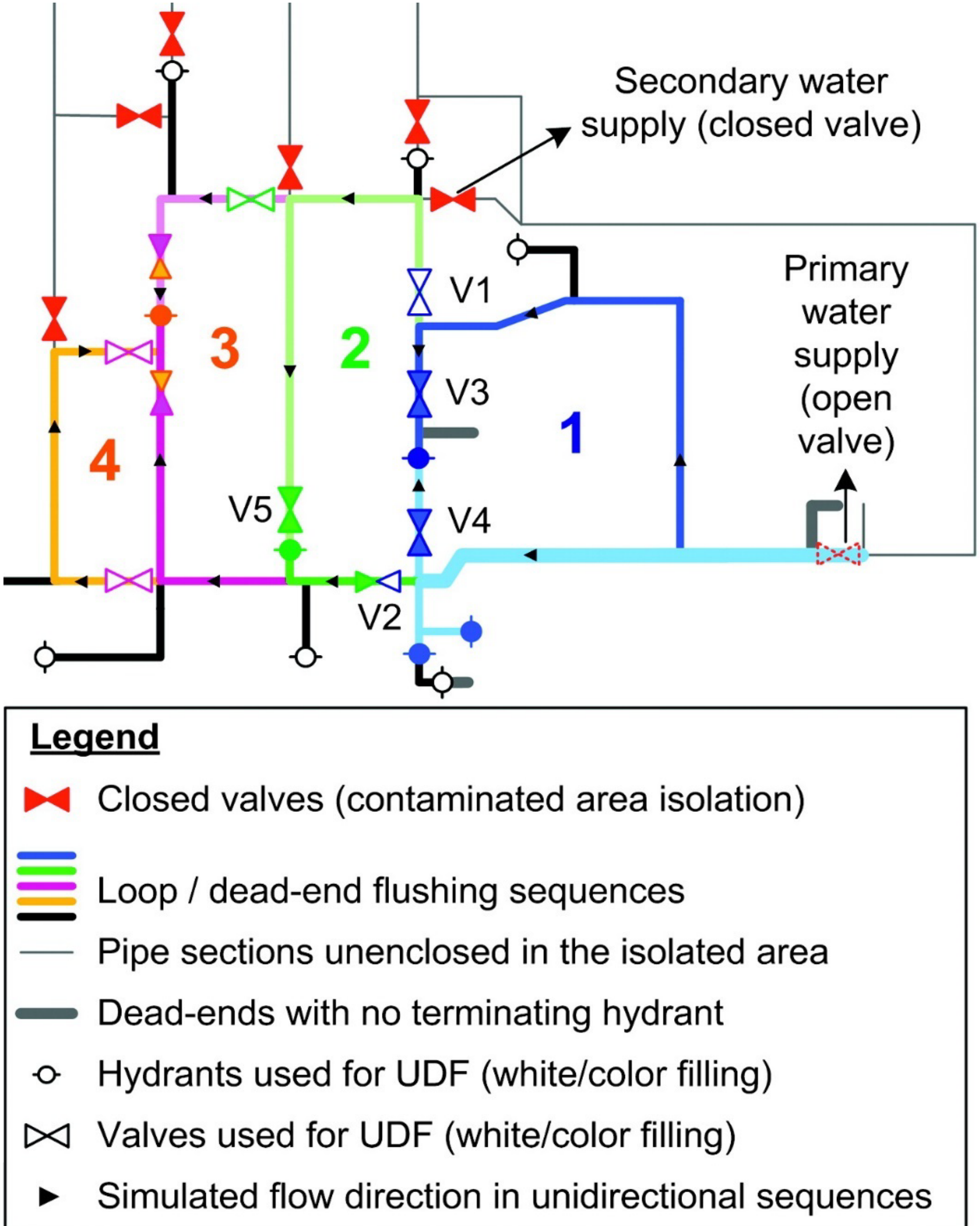
What is UDF?



Secondary water supply (closed valve)
Primary water supply (open valve)
V1
V2
V3
V4
V5
1
2
3
4
Legend
Closed valves (contaminated area isolation)
Loop / dead-end flushing sequences
Pipe sections unenclosed in the isolated area
Dead-ends with no terminating hydrant
Hydrants used for UDF (white/color filling)
Valves used for UDF (white/color filling)
Simulated flow direction in unidirectional sequences

Define SPU Flushing Criteria

- Target Flushing Velocity of 5 fps
- Ensure pressure is greater than 20 psi to protect public health
- Start from clean water interface (tank or large-diameter main that has been flushed)
- Run hydrant to obtain 3 pipe volume exchange at target velocity
- Then turn down flow at hydrant and flush at low flow (approx. 200 to 300 gpm) until turbidity is less than 2 NTU
- Try to develop loops with similar pipe diameter (if possible)
- Include dead ends (use blow off or services to flush)
- Pre-determined disposal locations for water (HUGE coordination effort with our drainage staff)

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Develop Sequence of Flushing Loops

- Develop individual loops (or flushed segments) based on:
  - Main pipe material and length
  - Placement of flush hydrant
  - Valves available to isolate main for unidirectional flow
- Tools used to develop loops include:
  - Comprehensive water and sewer GIS
  - Current Map Book information
  - EPANET hydraulic model for zone
- Hardest loops to develop include large diameter mains with few isolation valves available
- Tried to use same flushing hydrant for sequential loops

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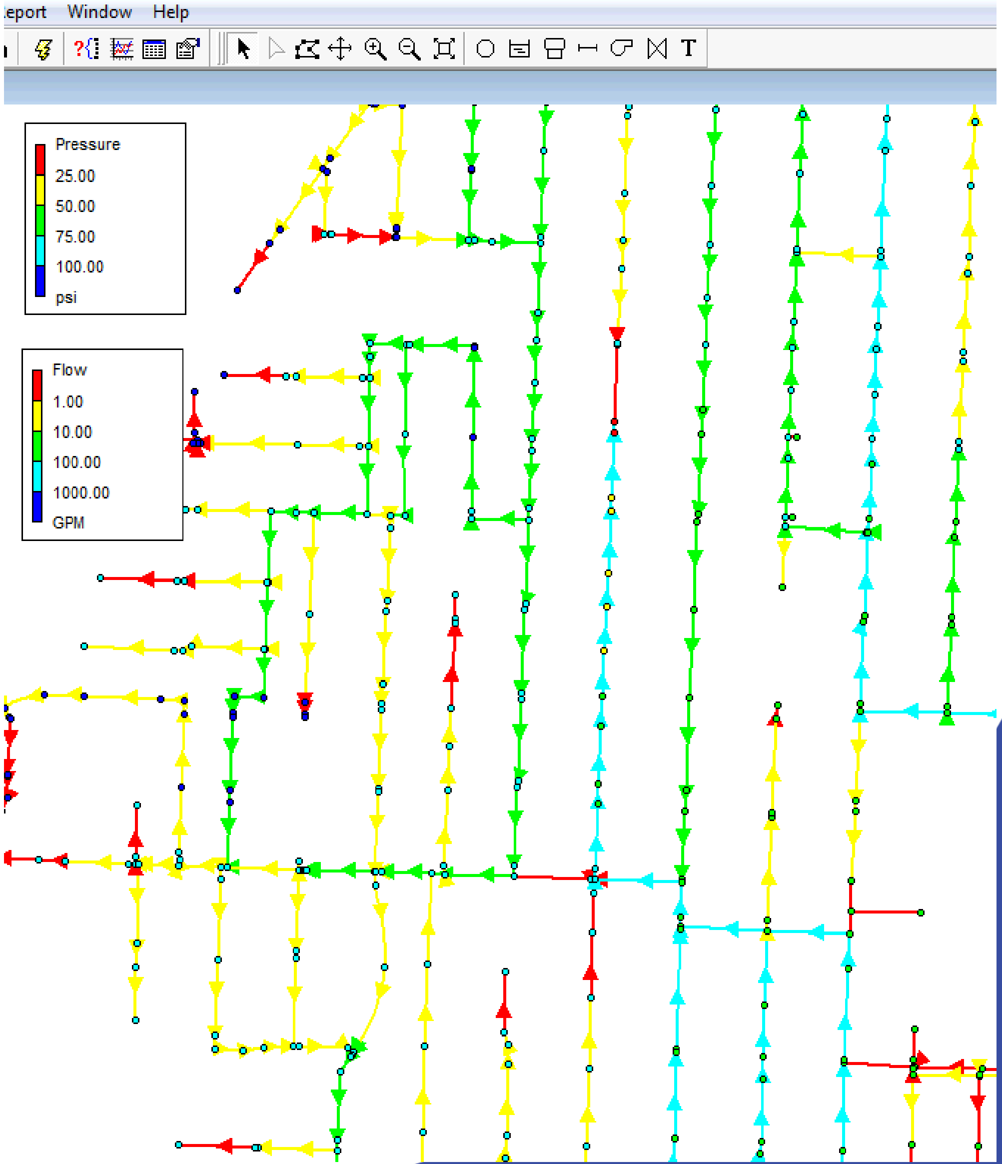
Use of Hydraulic Model

- SPU model is still in EPANET
- Run model for each loop to determine:
  - Which valves to close to ensure unidirectional flow through main
  - Location of low pressures
  - Approximate hydrant flow available



Field Maps

- Drew by hand individual loops on map book pages
- Worked with GIS staff to develop field map symbology, background, etc.
- Developed a field map for each flushing loop

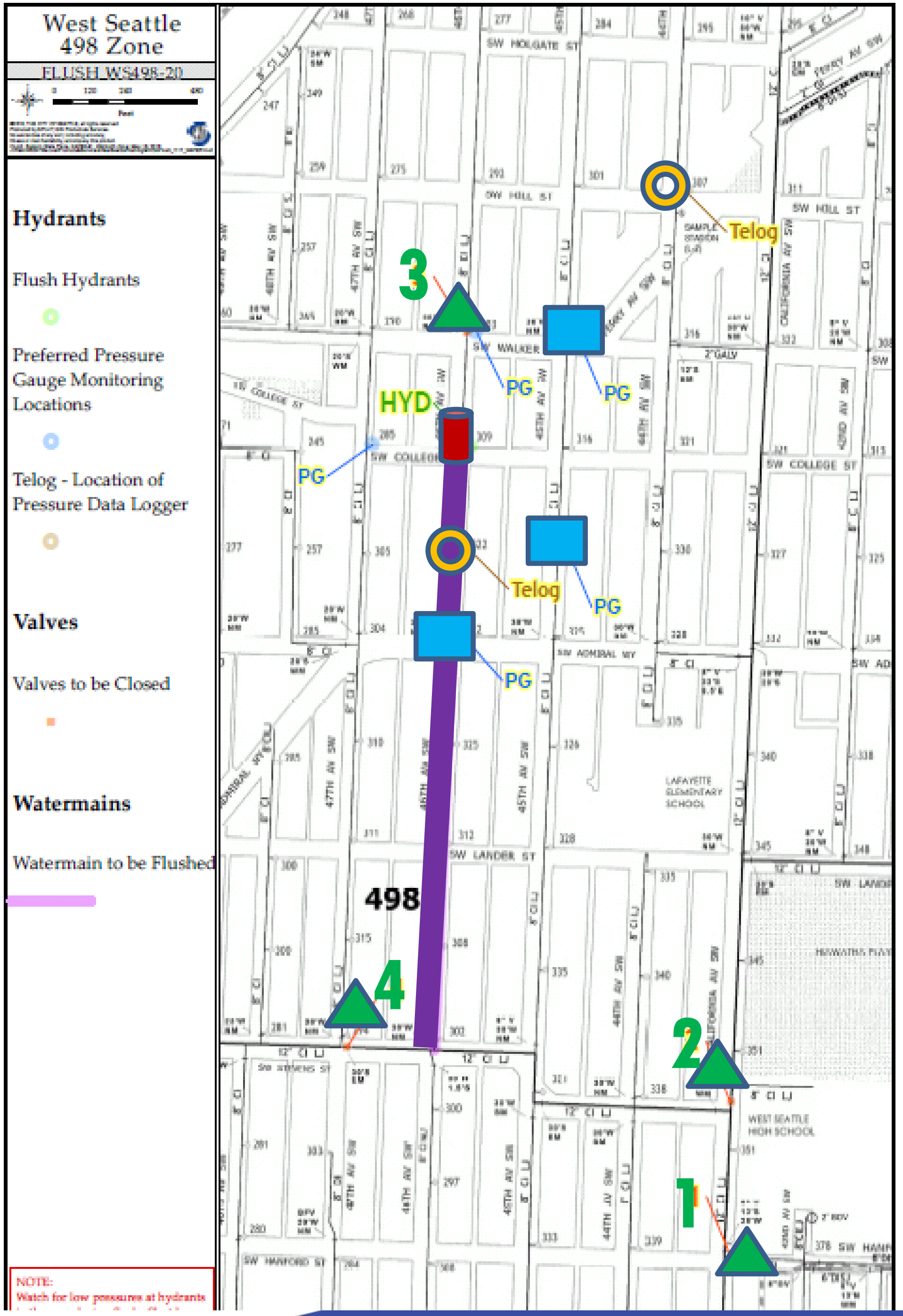
Main to be Flushed

Flush Hydrant

Closed Valves

Telogs Monitors

Pressure Gauges



Develop Field Logsheets

SPU Wa

Loop Identification

Maximo WO #:	*6741990*
Date:	*5/17/2016*
Start time on site:	*10:30 PM*
End time on site:	*1:15 AM*

Flush No: **WS 498-20**
Map Book Page: 48
Pressure Zone: WEST SEATTLE 498
Flush Hydrant Asset No: 91763

FLUSHING HYDRANT (FH):	46th Ave SW and SW Colle

Flush Hydrant Location

LOCATION OF VALVES TO BE CLOSED	EM	WM	SM	NM	Mark Valves When Closed (C) and Opened (O)
California Ave SW and SW Hanford St	**1**				
California Ave SW and SW Stevens St				**2**	
46th Ave SW and SW Walker St				**3**	
SW Stevens St and 47th Ave SW	**4**				

Valves to be Closed

Target Flow Rate and Flush Duration

Water Main **DIAMETER**	**8 in**	Target **FLOW RATE** for 5 fps Velocity	**800 gpm**	**TIME** to Flush at High Velocity to Expel 3 Pipe Volumes	**20 minutes**

Develop Field Logsheets

High Velocity Flush START TIME	High Velocity Flush END TIME	High Velocity Flush TIME	High Velocity Flush ACTUAL FLUSH	High Velocity ACTUAL FLUSH
11:00 PM				

High Velocity Flush – Time, Rate, Volume

Low Velocity Flush START TIME	Low Velocity Flush END TIME	Low Velocity Flush TIME TO CLEAR (minutes)	Low Velocity Flush ACTUAL FLUSH RATE (gpm)	Low Velocity ACTUAL FLUSH VOLUME (gallons)
11:30 PM				

Low Velocity Flush – Time, Rate, Volume

CHLORINE (mg/L)	INITIAL (after barrel flush)	DURING (after high velocity flush)	FINAL (at end of low velocity flush)	Notes
	.31	*.41*	*.65*	

Field Water Quality Results – Cl2 and Turbidity

TURBIDITY (mg/L)	INITIAL (after barrel flush)	DURING (after high velocity flush)	FINAL (at end of low velocity flush)	Notes
	1.3	*17.1*	*1.96*	

FLUSH HY… PRESSURE…	…	…ESIDUAL …FLOW (psi)
90 PSI	*12 PSI*	*82 PSI*

Hydrant Pressures – static and during

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Develop Field Logsheets

RECEIVING WATER NEARBY? (Y or N and describe or name)	DISCHARGE DECHLORINATED? (Y or N)	FIELD pH	TOTAL CHLORINE (mg/L)
STORM DRAIN			*.05*

Dechlor Information

LAB ANALYSIS SAMPLES COLLECTED? (Y or N)	METALS SAMPLE? (Y or N)	BACTERIOLOGICAL SAMPLE? (Y or N)	NOTES
Y			

WQ Samples Collected for Lab Analysis

TYPE OF FLUSH EQUIPMENT USED (Hose Monster, Pollard? with hose? etc.)
HOSE MONSTER WITH SOUND BARRIER *5' RED FLUSHING HOSE*

Equipment Notes

Main Diameter (in):	8
Main Length (ft):	2035
Main Volume (gal):	5,310
Main Type	CI
Year Installed	1910

Target Flush Velocity (fps):	5 fps
Target Flush Flow Rate (gpm):	800
Target Number of Pipe Volumes:	3
Target Flush Volume (gal):	15,930
Time to Achieve 3 PVs at High Velocity	20 minutes

NOTES / COMMENTS
HYD 46TH AND WALKER STAIC 80, HIGH FLOW 78, LOW FLOW 80
HYD 45TH AND WALKER STAIC 75, HIGH FLOW 75, LOW FLOW 75
FLUSH WENT GREAT

Field comments

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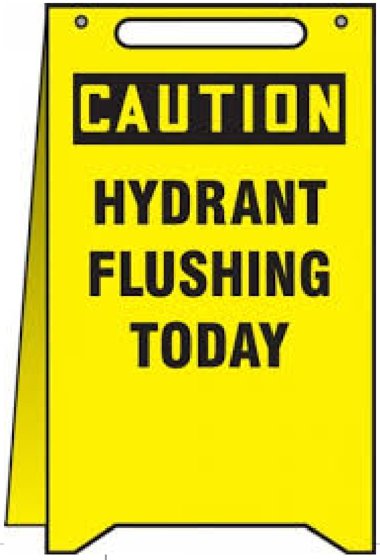
Determine Length of Flush

- Set up calculations to determine length of flush at target velocity
- Duration based on turnover of 3 pipe volumes
- Dependent on pipe diameter, estimated flow and length of loop/segment
- Crew has flexibility to lengthen if flushing target velocities aren't met
- Low velocity flush (200 to 300 gpm) conducted until turbidity measured less than 2 NTU

West Seattle Flushing Program										Flow rate for 5 fps					
Flushing Time and Volume Calculations										2 inch	49 gpm	6 inch	441 gpm	10 inch	1224 gpm
										4 inch	196 gpm	8 inch	784 gpm	12 inch	1763 gpm
Flush No	Diameter	Length of Main Flushed	Area	Area	Volume	Volume	3 Pipe Volumes	Flow rate	Time To Flush	Time To Flush - Rounded UP	Hydrant Flushing Number				
	in	LF	sq in	sq ft	cu ft	gallons	gallons	gpm	minutes	minutes					
34A	8	220	50.27	0.35	77	574	1,722	25	68.8866	69.00		8 inch	CI	1926	service
35	8	1100	50.27	0.35	384	2,870	8,611	800	10.7635	11.00	**96504**	8 inch	CI	1955/56/57	
36	8	975	50.27	0.35	340	2,544	7,632	800	9.5404	10.00	**94943**	8 inch	CI	1958/70	
37	6	605	28.27	0.20	119	888	2,664	450	5.91994	6.00	**95482**	6 inch	CI	1949	
38	8	1850	50.27	0.35	645	4,827	14,482	800	18.1023	19.00	**97847**	8 inch	DI/CI	1997 DI and 1910/1953 for CI	

Set Schedule

- Generate schedule based on what crews can get done in one day/night
- Set schedule and communicate changes daily
- Keep log to track issues/delays



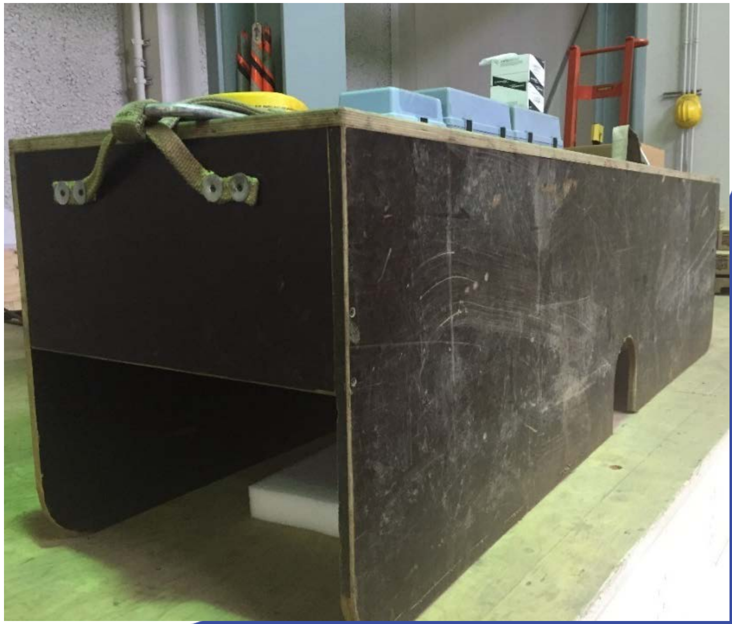
WEST SEATTLE FLUSHING PROGRAM

FLUSH AREA 1 - NORTH END OF 498 ZONE

DATE (2016)	DAY	PLANNED FLUSHES	GENERAL LOCATION	SPECIAL NOTES FOR FLUSHES	ACTUAL FLUSHES COMPLETED	NOTES (including reasons for schedule changes)
June 27	Monday	35 36	48th Ave SW and SW Walker St		38 38B	38A - BO was paved over, no services, no flush
June 28	Tuesday	37 38	48th Ave SW and SW Walker St (37) and SW Hanford St and Walnut Ave SW (38)		30 30A 31	
June 29	Wednesday	38A 38B 39	SW Hanford St and Walnut Ave SW (38A and B) and Ferry Ave SW (39)	38A- 8-inch through 2-inch BOV	32 32A 32B	For 32B - Flushed for 2 hrs and on got 4.01 NTU

Procure Equipment

- Hose Monster Big Boy Diffuser set up
- Hydrant and Valve wrenches
- De-chlor tablets and mats
- Pressure Gauges
- Telog pressure monitoring equipment (for future hydraulic model calibration)
- SPU built a 'sound box' to lessen noise at night
- Water quality sampling/monitoring equipment
- Extra Hose and fittings to direct flow from hydrant
- Recommend flow meters at hydrant



Equipment

BigBoy Hose Monster Bundle

Flow through the 4 inch or 4 ½ inch hydrant port with the BigBoy Hose Monster™

Item #	Description
HMBB4	The BigBoy Hose Monster™
HGV45NST	Gate Valve
HMRR12	Remote Reader Assembly
GCSW160	Gauge Cap
HW107	Hydrant Wrench
WSPA101	Spanner Wrench
CASE720	Gauge and Accessory Case
H45.10.4	4 ½ inch F NH X 10' foot X 4 inch M NH

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Crew Requirements

- SPU Flushing conducted at night
- Used 3 to 4 member crews
- Tried to maintain consistent staffing throughout project
- Additional personnel may be required for:
  - Directing/monitoring disposal of water
  - Pressure monitoring in system
  - Handing out notices/setting sandwich boards (during day)
  - Preparatory field work (during day)

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Crew Training

- Review objectives and criteria of UDF program
- Show how to interpret (and change as necessary) field maps
- Go over what to include on log sheets for documentation
- Experiment with flushing equipment on a hydrant in your operations yard
- Teach how to use chlorine test kit and portable turbidimeter
- Show proper techniques for water quality sampling (total coliform and metals)

Preparatory Work in Field

- Exercise hydrants and valves to be used
- Check equipment, outfit flushing truck
- Order WQ and dechlor supplies
- Set up sandwich boards
- Review opening/closing of valves to prevent loss of service to customers
- Check functionality of blow-offs if used for flushing
- Set Telog Pressure Data Recorders (data collected for future model calibration)

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Field Coordination

- SPU designated a Field Coordinator (~ 0.8 FTE) for duration of West Seattle 498 Zone flushing program
- Field Coordinator responsibilities included:
  - Obtain and maintain noise permits
  - Print out and deliver maps/log sheets for crews
  - Communicate with team daily regarding ever-changing schedule
  - Coordinate with drainage staff for flushing water disposal
  - Coordinate with day crews for pre-flushing field checks (valve and hydrant operations by crews)
  - Track Customer Complaints
  - Keep Fire Department informed
  - Work to solve any problems that arise

Key Communication Pathways During Flushing

- Started by developing an internal communication strategy for the project
- Mailer sent out prior to start of flushing to all in area
- Regular communication with local, active blog
- Flyers provided on sandwich boards in area of flush with contact name and phone number
- Door to door delivery of notices to homes within 200 ft of flushing hydrant for noise ordinance
- Field crew interaction with public during field work
- Information posted on website regarding flushing

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West Seattle UDF Flushing Program Summary

- Started developing program in mid March 2016
- Conducted April 23 through August 11, 2016
- Completed 130 flushing loops
- 21 miles of pipe, predominantly CI, 2 to 16 inch
- Velocities achieved were less than target of 5 fps
- Saw increase in chlorine residual at end of flush most of the time
- Successful in getting turbidity less than 2 NTU at end of low velocity flush
- Good results from water quality sampling conducted (TC and metals) throughout program
- Very few complaints during flushing program and less in general since flushing completed
- Many lessons learned in development, operation, coordination and documentation of UDF program

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Water Main Flushing
West Seattle
Active Flushing Area
Flushing Area Completed in 2016
Puget Sound
Elliott Bay
NORTH ADMIRAL
ALKI
Alki Ave SW
Harbor Ave SW
California Ave SW
SW Admiral Way
49th Ave SW
SW Hanford St
37th Ave SW
35th Ave SW
63rd Ave SW
59th Ave SW
55th Ave SW
Beach Dr SW
SW Spokane St
SW Charlestown St
SW Manning St
SW Genesee St
SW Avalon Way
West Marginal Way SW
23rd Ave SW
N
Miles

Diameter of Pipe in Loop (in)	Average Loop Length (LF)	Range of Loop Lengths (LF)	Flush Rate Required for 5 fps (gpm)	Average Flush Rate (fps)	Range of Velocities Achieved (fps)	Total Loops	% of Loops where Chlorine Increase was Observed	% of Loops where Turbidity Measured Less than 2 NTU
2	378	60-860	50	35	1.0 to 5.1	11	64	91
4	815	140-815	200	80	0.5-5.1	3	0	100
6	415	110-815	450	380	0.2 - 8.5	14	43	100
8	1000	50-2675	800	690	1.9- 7.0	84	49	87
10	848	285-1600	450-1250	783	1.8-3.4	3	33	67
12	1250	42-2325	1800	1200	1.7-4.5	13	23	77
16	2180	1920-2440	1800	1050	1.3-2.1	2	50	50
					Total	130		

WQ Sampling

- Collected samples after low-velocity flush to test water that customers would drink
- Sampled for Total Coliform/HPC and metals
- Only 2 TC+ samples (low HPCs) – attributed to sampling equipment
- Metals of note:

PARAMETER	Iron	Manganese	Arsenic	Lead
RANGE (mg/L)	0.04 – 1.0	0.002 – 0.04	0.0004 – 0.0017	0.006 – 0.007
MCL/SMCL/AL (mg/L)	0.3	0.05	0.010	0.015

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WRF Study

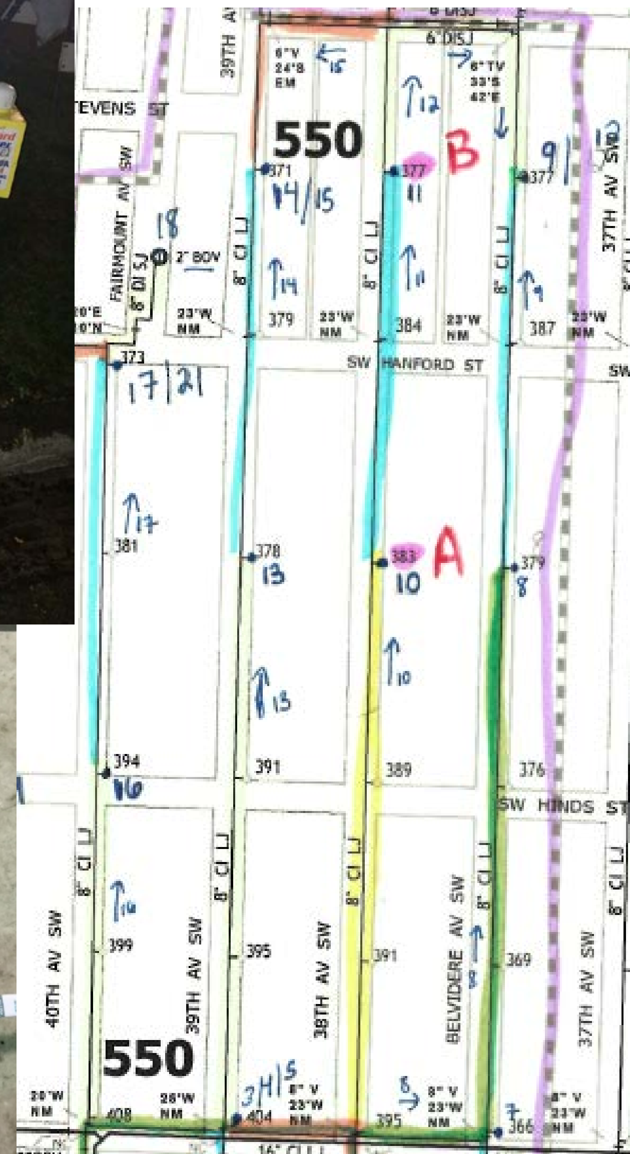
- SPU and Portland Water Bureau participated in WRF Study #4653 Ensuring Flushing is a Corrective Action Under RTCR
- Objectives of study include:
  - Applicability of different flushing techniques for microbial control and mitigation
  - SOPs for flushing and data collection
  - Cost vs. benefit to support investment in flushing
- SPU conducted UDF and Spot flushing pilots in West Seattle during fall 2016
- PWB is conducting trials now (Spring 2017)
- Working with Confluence Engineering Group

WRF Study

- Areas selected for flushing pilots:
  - Exhibit historical WQ challenges
  - Small areas, well gridded with uniform pipe conditions/type
  - Nearby clean water interface
- Conduct WQ baseline monitoring (~4 weeks)
- Collect samples during flush profile (0, 0.5, 1, 2, 3, 4 pipe volumes)
- Wide array of analytical parameters (field parameters, metals, microbial)
- Conduct response monitoring within DS after flushing is complete

WRF Study

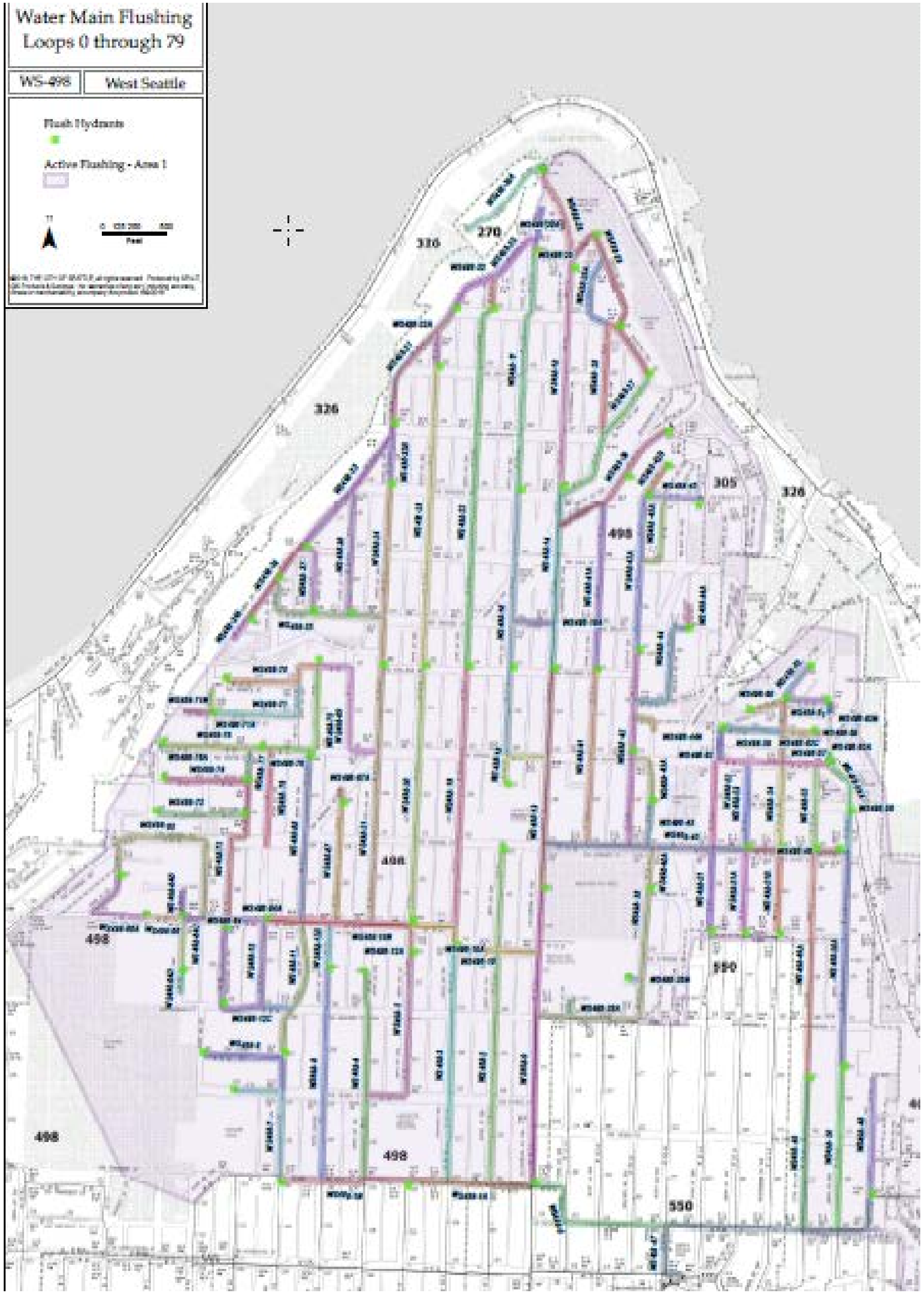
Water Research Foundation℠



Where Does SPU Go from Here?

- Compiling results of 498 Zone flushing project, NO-DES pilot and WRF project
- Working to build a regular UDF program
- Requires dedicated crews and engineering help to develop loops ($$$)
- Optimistic we will be flushing again this summer!

Hydrant Flushing
Enhancing Water Quality



Questions?

Paige Igoe, PE
Senior Water Quality Engineer
Seattle Public Utilities
P: 206 684 9233
E: Paige.Igoe@seattle.gov

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