Final BMP Evaluation Report

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Final Monitoring Report

Biofiltration Swale Longevity Effectiveness Evaluation

Approved by:

I certify, under penalty of law, that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for willful violations.

Signature: Tony Bush Date: 10/27/2025

Tony Bush, Stormwater Branch Manager

WSDOT Environmental Services Office

Signatures are not available on the Internet version.

WSDOT = Washington State Department of Transportation

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Executive Summary

From 2020 through 2024, the Washington State Department of Transportation (WSDOT) completed an effectiveness evaluation of Biofiltration Swales greater than 20 years old at two locations in Western Washington, SR 500 (Vancouver) and SR 18 (Mirrormont). This performance evaluation includes water quality and hydrologic data collection and analysis to support WSDOT's Highway Runoff Manual (HRM) and WSDOT Maintenance and Operations.

A goal of the study was to improve understanding of how age affects biofiltration swales and how swales perform past the HRM life expectancy. This information will be used to inform future versions of the HRM and maintenance manuals.

Technology Description

The biofiltration swale consists of a flat-bottomed, shallow-sloped swale planted with grasses. The swales function by slowing runoff velocities, filtering out sediment and other pollutants, and providing some infiltration into underlying soils. Concentrated flow from the roadway section is directed to the high end of the swale. (HRM, 2019)

Sampling Procedures

Two monitoring study sites were selected along the roadside adjacent to WSDOT owned and operated highways. Both sites provided paired hydrological and chemistry data for comparison of the current BMP to the level of treatment that they were originally designed for.

To evaluate bioswale performance, monitoring procedures and methods in the *Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies – Technology Assessment Protocol – Ecology (TAPE)* (Ecology, 2019) were followed. Automated samplers were used to collect flow-weighted composite samples from influent and effluent sampling points at each BMP. Samples were collected from 15 separate storm events from 2022 through 2024.

Laboratory analyses of the collected flow-weighted composite samples included the following water quality parameter:

- Total suspended solids (TSS).

Hydrologic Performance

The bioswales studied exhibited an overall volume reduction of approximately 57.6 percent of runoff. The Mirrormont swale had a 92.75 percent reduction in stormwater volume. This reduction in volume is the primary reason for the reduction in pollutants.

Water Quality Performance

The Vancouver swale met treatment goals for TSS, and the majority of pollutant removal occurred through infiltration. In addition to infiltration, the swale is also reducing concentrations through processes of adsorption and filtration.

Technical Guidelines

Following guidelines in TAPE (Ecology, 2018) and requirements in the WSDOT NPDES municipal stormwater permit (Ecology, 2019), Appendix A presents storm reports, hyetographs, and hydrographs for each sampling event. Table 5 provides analytical data for all sampled storms.

Data interpretations and analyses in this report include:

- Summary statistics of all collected pollutants.
- Statistical pollutant removal efficiencies.
- Calculation of pollutant concentrations percent removal and total pollutant load removal.
- Bootstrapping to compute confidence intervals around mean pollutant removal.

1 Introduction

1.1 Background

The Washington State Department of Transportation (WSDOT) is responsible for maintaining more than 7,000 miles of highway, 48 high-use rest areas, 24 maintenance facilities, and 19 ferry terminals. The stormwater generated by the impervious surfaces at highways and facilities like these is regulated under the U.S. Environmental Protection Agency's (EPA) National Pollutant Discharge and Elimination System program (NPDES), if they are located within permit coverage areas. In Washington, EPA delegated NPDES permit development and issuance authority to the Washington State Department of Ecology (Ecology), and Ecology implements these regulations at the state level.

This report describes the monitoring effort conducted during effectiveness monitoring of stormwater treatment and hydrologic BMPs at two WSDOT highway sites (hereinafter "highways") to meet permit requirements (Ecology, 2019). Stormwater monitoring provides feedback to WSDOT for support of maintenance activities outlined in the Highway Runoff Manual (WSDOT, 2019). WSDOT's stormwater management approach utilizes BMPs to help meet the permit requirement to "reduce pollutants in discharges to the maximum extent practicable" (Ecology, 2019). The monitoring program evaluates performance of BMPs using guidance in the Technology Assessment Protocol – Ecology (TAPE) (Ecology, 2018) as required by S7.C of the permit.

The BMPs assessed under this report include two biofiltration swales used to treat highway runoff with differing construction and highway location designs. Both sites are in western Washington. The effective life of a biofiltration swale as stated in the HRM is 5-20 years. For this study, WSDOT monitored swales beyond the longest effective age (20+ years), this information may allow WSDOT to adjust its maintenance and replacement schedules of biofiltration swales.

1.2 Designs

Biofiltration swales are described in the Washington State Department of Transportation (WSDOT) Highway Runoff Manual (HRM) (WSDOT, 2019). Biofiltration swales are vegetation-lined channels designed to remove suspended solids from stormwater. The shallow, concentrated flow within these systems allows for the filtration of stormwater by plant stems and leaves. Biological uptake, biotransformation, sorption, and ion exchange are potential secondary pollutant-removal processes. Biofiltration swales are currently approved for basic runoff treatment.

Biofiltration swales have a low to moderate capital cost and a low to moderate maintenance and operation cost. Biofiltration swales have the flexibility to be located at the end of a stormwater

collection system, and designers can regard roadside ditches as significant potential biofiltration sites and should utilize them for this purpose whenever possible.

1.3 Project Overview and Timeline

WSDOT initiated a monitoring effectiveness evaluation in 2020 to test the life expectancy for bioswales and to satisfy requirements under Special Condition 7.D (S7.D) of the department's National Pollutant Discharge Elimination System and State Waste Discharge Municipal Stormwater General Permit (permit) (Ecology, 2019). The department installed monitoring sites at two locations in western Washington. At each location, WSDOT installed monitoring equipment and analyzed performance of existing 20+ year old bioswales.

No modification was performed on the existing bioswales. WSDOT surveyed and observed the swales and their drainage areas to ensure that the swale and contributing drainage area are functioning as originally designed. The experiment tested the TSS removal capabilities of the bioswales past their life expectancy. Results showed that the bioswales still meet the TAPE basic removal standards.

2 Sampling Procedures

This chapter provides a physical description of the study sites including site locations, site designs, and drainage areas. Other sections in this chapter describe monitoring station installations, equipment, water quality and hydrologic data collection methods, station maintenance, equipment cleaning, and quality assurance and quality control procedures.

The *Quality Assurance Project Plan (QAPP) for WSDOT Roadway Stormwater Treatment Evaluation: Best Management Practices* (WSDOT, 2020) provides a more detailed description of the monitoring site designs, sampling protocols, and methods used in this study. There were no deviations from the sampling procedures identified in the monitoring QAPP.

2.1 Monitoring Study Sites

This BMP effectiveness evaluation compares existing bioswales at two locations in western Washington. In 2021, WSDOT established study sites along State Route (SR) 18, Issaquah Hobart Rd off-ramp (Mirrormont), and the SR 500, SR 503 intersection in Vancouver.

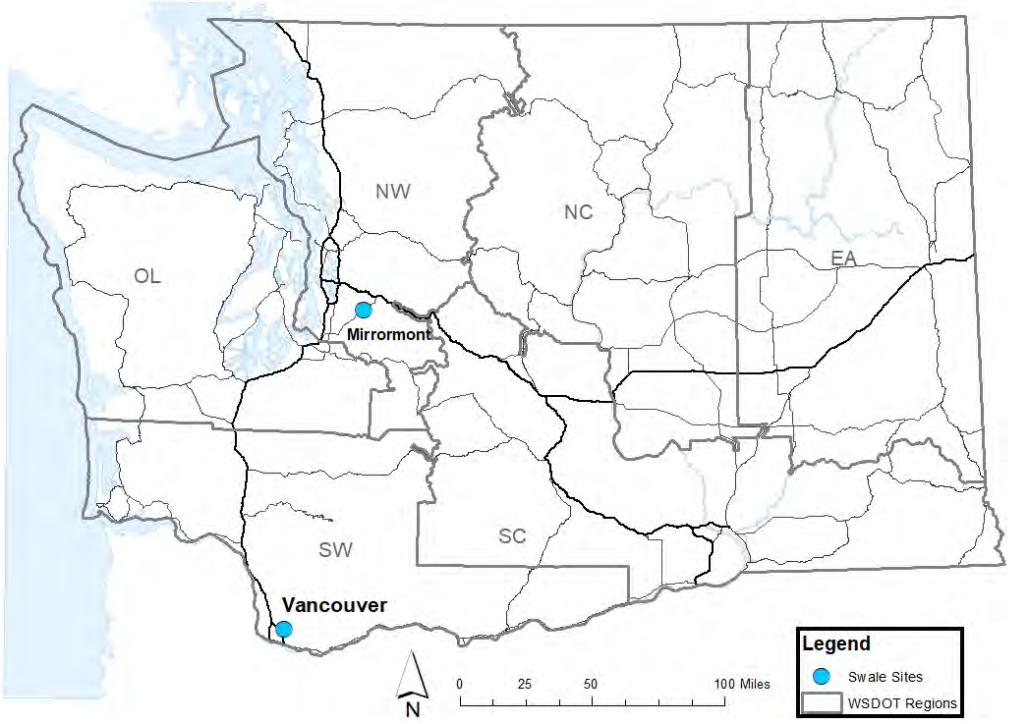

Figure 1 BMP locations for stormwater monitoring

Following guidelines in the WSDOT *NPDES* permit (Ecology, 2019), WSDOT used annual average daily traffic (AADT) values to categorize Vancouver and Mirrormont study sites as urbanized and rural, respectively. Each study site consisted of a bioswale constructed prior to the year 2000.

Table 1 Monitoring study sites

Site	Location	BMP Type	Traffic Designation[1]
Vancouver	SR 500 MP 7.00	Bioswale	20,000 AADT
	SR 503 MP 1.05		41,000 AADT
Mirrormont	SR 18 MP 20.50	Bioswale	25,000 AADT

[1] Annual average daily traffic (AADT) values from the WSDOT Annual Traffic Report (WSDOT, 2020).

Study Site 1 – Vancouver

The Vancouver biofiltration swale is located at milepost 7.00 on SR 500 and treats stormwater from the intersection of SR 500 and SR 503. The biofiltration swale was built for Clark County in 1999 and came under WSDOT ownership in 2005 when Padden Park Way became SR 500.

The biofiltration swale is located northeast of the intersection and receives runoff from an approximately 1-acre drainage area. The stormwater conveyance system is highlighted in Figure 2. The drainage area was ground-checked through multiple site observations during storm events, including heavy rain events. The biofiltration swale does not receive water from local roads or any non-WSDOT property.

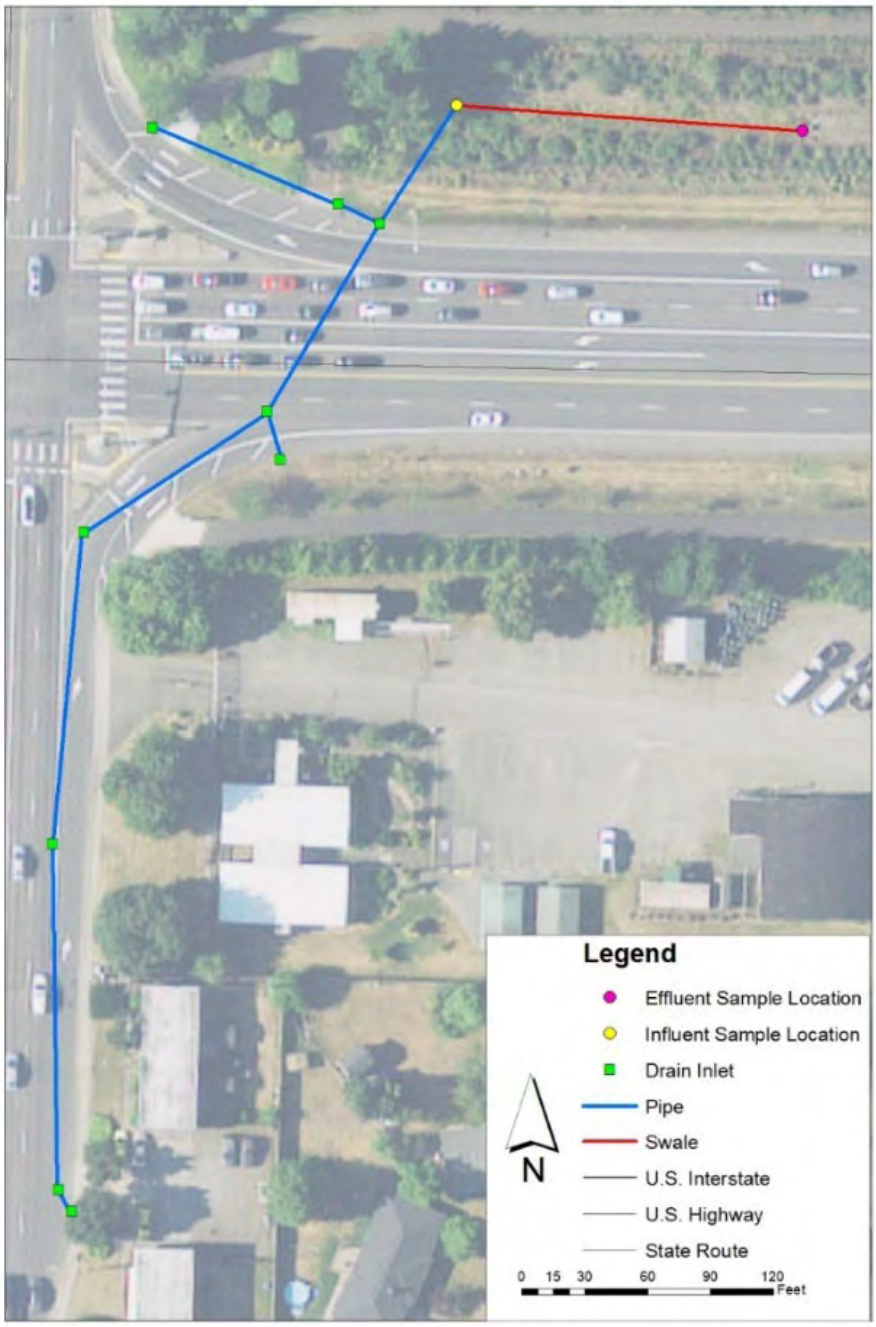

Figure 2 Vancouver biofiltration swale monitoring site and associated drainage features

A mix of grass and herbaceous species characterize the vegetative cover at the Vancouver study site. Vegetative cover at this site is nearly 100 percent.

Field crews installed H flumes at the influent pipe to the swale, and at the effluent pipe (see figures 3 and 4). Staff installed data collection platforms (DCPs) to house stormwater monitoring equipment (e.g., data loggers and autosamplers).

Figure 3 Vancouver effluent flume and monitoring station

Figure 4 Vancouver influent flume and monitoring station

Study Site 2 – Mirrormont

The Mirrormont biofiltration swale is located at milepost 20.48 on SR 18 and treats stormwater from SR 18 mainline lanes. The Mirrormont biofiltration swale was built to 1995 HRM standards in 1999.

The biofiltration swale is located on an offramp north of mainline SR 18 and receives runoff from an approximately 3.5-acre impervious drainage area. The stormwater conveyance system is highlighted in Figure 5. The drainage area was ground-checked through multiple site observations during storm events, including heavy rain events. The biofiltration swale does not receive water from local roads or any non-WSDOT property.

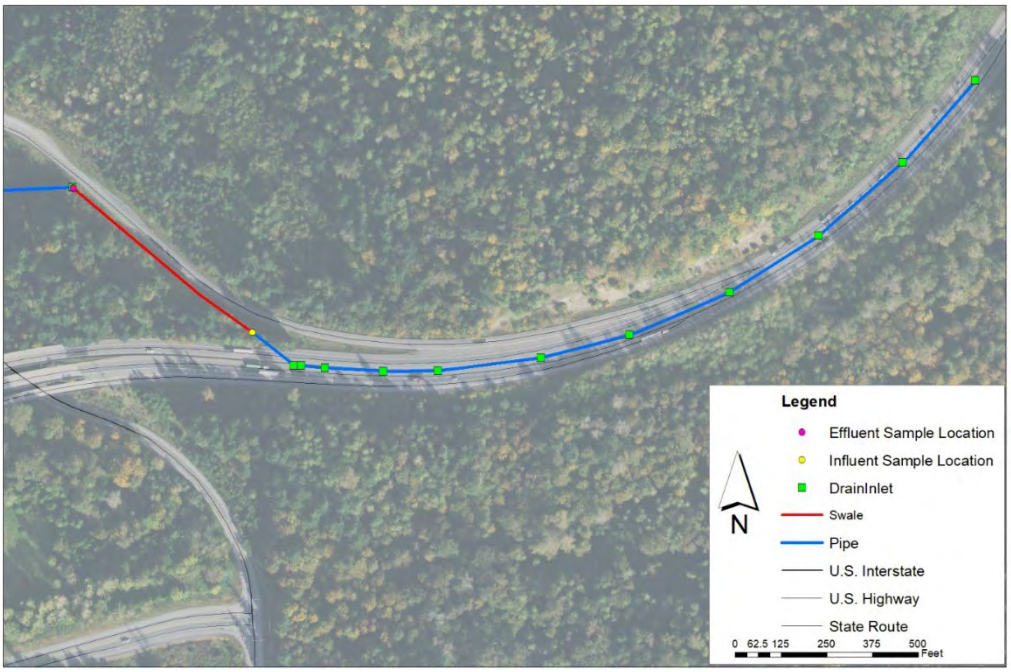

Figure 5 Mirrormont biofiltration swale monitoring site and associated drainage features

A mix of grass and herbaceous species characterize the vegetative cover at the Mirrormont study site. Vegetative cover at this site is nearly 100 percent.

Field crews installed H flumes at the influent pipe to the swale, and at the effluent (see figures 6 and 7). Staff installed data collection platforms (DCPs) to house stormwater monitoring equipment (e.g., data loggers and autosamplers).

Figure 6 Mirrormont effluent flume and monitoring station

Figure 7 Vancouver influent flume and monitoring station

2.2 Site Designs

WSDOT staff installed one foot H Flumes at the influents of both sites. Flumes were connected with mortar and Trex boarding to the influent pipe ensuring that all water entering the swale was channeled through the flume.

Flumes were installed with sufficient elevation change to enable accurate flow measurement. At the Vancouver site, the influent received runoff from seven lanes of traffic at the SR 500/SR 503 traffic light and paved shoulders. At Mirrormont, the influent received runoff from two

lanes of traffic and a paved shoulder. Figures 8 and 9 provide a general illustration of the Vancouver and Mirrormont monitoring site designs.

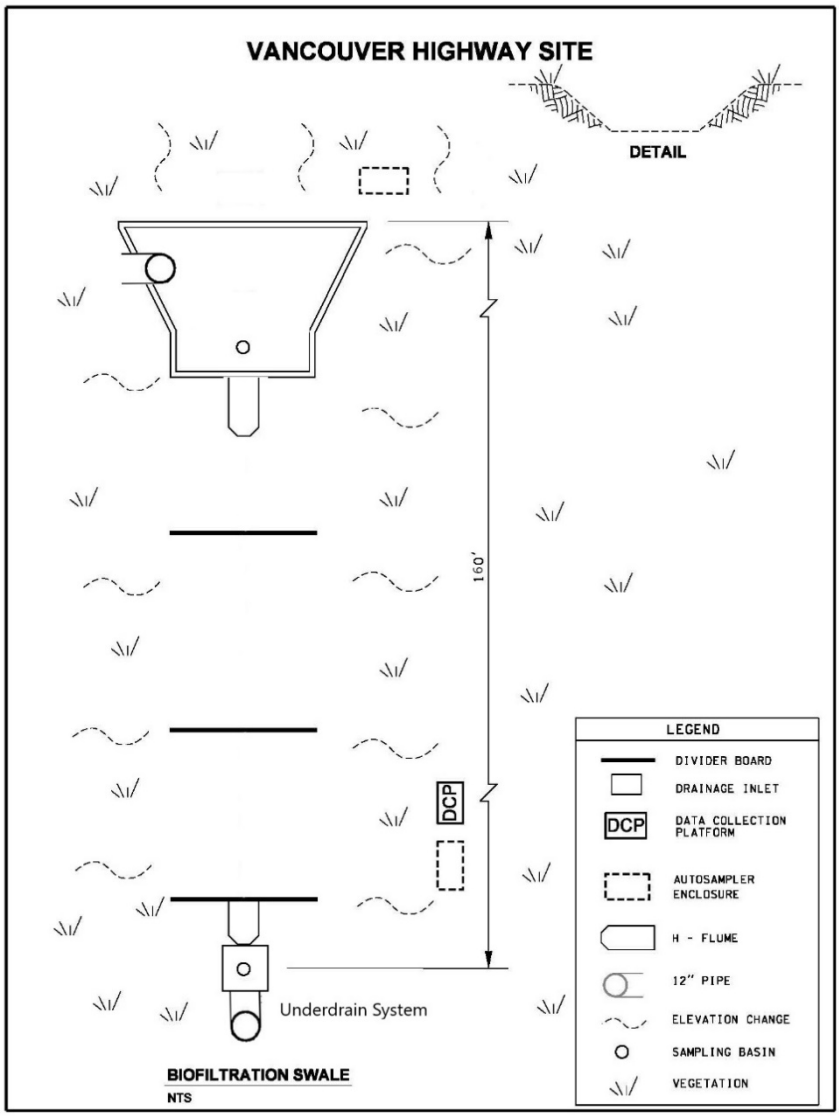

Figure 8 Vancouver swale design

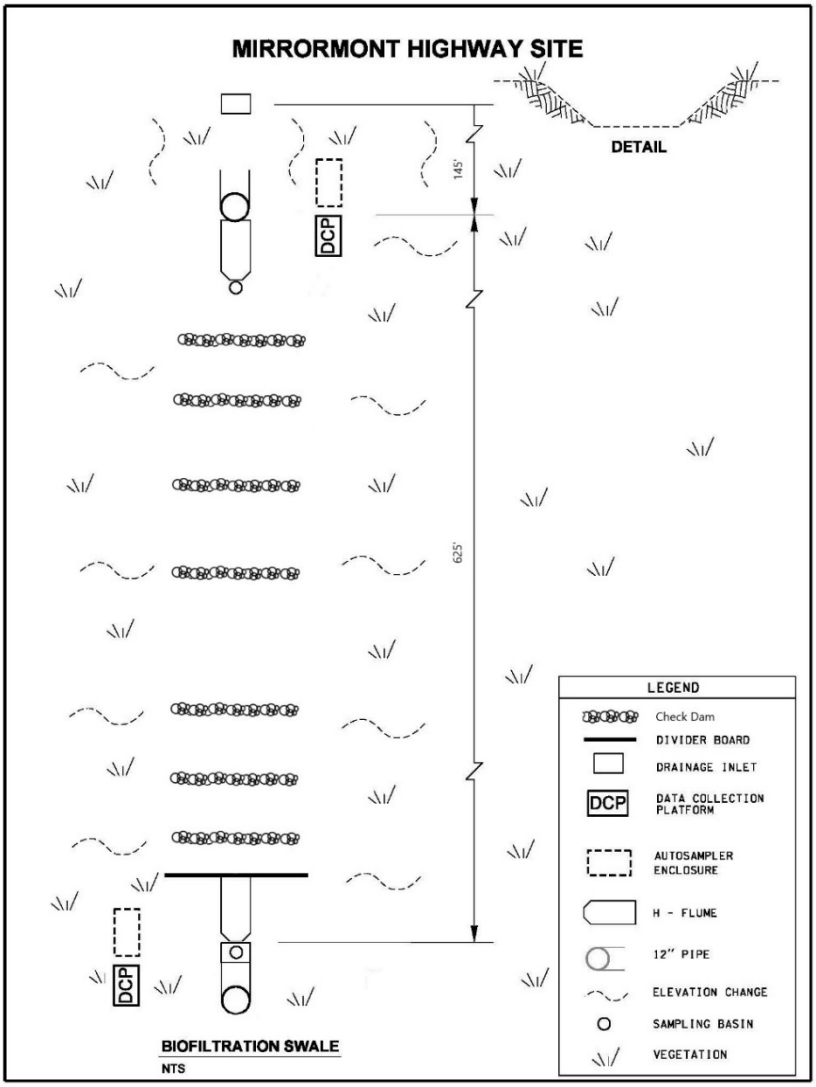

Figure 9 Mirrormont swale design

2.3 Monitoring Stations

Data collection platforms at the Vancouver and Mirrormont monitoring sites included an equipment enclosure with lock, Global Positioning System, antenna, solar panel, and rain gauge. A mast attached to the side of the enclosure supported the antenna, solar panel, and rain gauge (Figure 10).

Equipment enclosures housed a data logger, refrigerated automatic sampler, and sampler tubing. Water temperature and stage height were measured at the flume by a temperature probe and radar.

Figure 10 Monitoring equipment

Sample tubing ran from the automatic sampler in the equipment enclosure to the designated sampling point through protective conduit. The radar and temperature probe connecting cables ran through conduit to the flume to collect stage and water temperature measurements. The locked enclosure provided a secure location for equipment, as well as protection from wind, rain, and snowfall.

Precipitation Measurement

At each monitoring station, a pole-mounted, tipping-bucket rain gauge was installed to measure on-site rainfall. Following National Weather Service protocols (NWS, 2010), field staff installed rain gages where no overhead structures would obstruct or divert precipitation. Data loggers recorded and stored precipitation measurements at 15-minute intervals. This data is used to track and record site-specific precipitation measurements.

Temperature Measurement

Water temperature readings were recorded at each monitoring DCP to fulfill permit requirements and to know when to deactivate or discontinue sampling in freezing or near freezing conditions. Data loggers automatically recorded and stored temperature measurements every 15 minutes, and then transmitted the measurements telemetrically to WSDOT's database. Storm event tables in Appendix A provide minimum and maximum temperature values recorded during sampling events.

2.4 Weather Tracking

Weather data, from satellite imagery, prediction models, the National Oceanic and Atmospheric Administration National Weather Service, and private forecasters, were used to forecast potentially qualifying storm events on a daily basis. As candidate storms approached, weather radar observations and hourly reports from land-based weather stations helped track and evaluate storm potential. Telemetered data transmitted from the individual monitoring DCPs was used to track progress of a storm event and the beginning of runoff. This information was used to direct field deployments for sample collection.

To qualify, storms had to meet rainfall depth and antecedent dry period guidelines described in *TAPE* (Ecology, 2018). Table 2 lists these storm event criteria.

Table 2 Storm event guidelines for BMP effectiveness monitoring

Parameter	Guidelines
Monitoring Period	Year round
Rainfall Depth	0.15-inch minimum; no fixed maximum
Rainfall Duration	1-hour minimum; no fixed maximum
Antecedent Dry Period	< 0.04-inch rain in the previous 6 hours

[1] Collect samples over a range of rainfall intensities to assess performance on an annual average basis and performance at the peak design rate.

2.5 Sampling Methods

BMP effectiveness monitoring sites were established to measure precipitation, stormwater surface flows, and water quality. Table 3 lists parameter categories, sampling frequency, and methods.

Table 3 Sampling methods overview

Parameter Category	Sampling Frequency	Sampling Method	Telemetered Data
Rainfall	Continuous, year-round	Rain gages	Yes
Stage (flow)	Continuous, year-round	Stage measuring devices	Yes
Temperature	Continuous, year-round	Stage measuring devices	Yes
Chemical	Discrete storm events	Autosamplers	No

Table 4 Sample collection requirements for automated, flow-proportional composite sampling

Parameter	Definition	Requirement
Minimum aliquot number	The number of equal-volume samples collected during a storm event that are combined to create a composite sample	10 aliquots
Storm event coverage	The percentage of the total storm volume that the collected aliquots represent	For storm events lasting less than 24 hours, samples shall be collected for at least 75 percent of the storm event hydrograph (by volume). For storm events lasting longer than 24 hours, samples shall be collected for at least 75 percent of the hydrograph (by volume) of the first 36 hours of the storm.
Maximum sampling duration	Time in hours between the collection of the first and last aliquots	36 hours
Minimum number of samples	Number of storm events with successfully collected flow-proportional composite samples that meet the influent concentration ranges and the storm event guidelines	15 samples

Other required parameters include:

- Storm ID or number.
- Location.
- Event rain (storm depth).
- Antecedent dry period.

- Storm duration.
- Influent and effluent volumes.
- Number of influent aliquots.
- Number of effluent aliquots.
- Percentage of influent and effluent storm volume sampled.
- Comparisons of data to storm event guidelines and sample collection requirements.

For further information regarding data collection activities, sample processing details, and analytical requirements for the BMP effectiveness evaluation, see the *Quality Assurance Project Plan WSDOT Roadway Stormwater Treatment Evaluation: Best Management Practices* (WSDOT, 2021).

2.6 Station Maintenance

The Department's monitoring staff initially conducted station maintenance visits every six to eight weeks. However, to address system cleanout and equipment calibration concerns, maintenance frequencies increased to a regular three-week schedule soon after the start of monitoring.

During each site maintenance visit, a visual inspection of the monitoring site was performed to identify possible damage to equipment and any new or unsafe conditions. Field teams checked equipment enclosures for signs of tampering or forced entry. Staff inspected and cleaned outlet pipes, sampling basins, and the conveyance system to ensure the monitoring stations were in good condition prior to sampling storm events. Field staff implemented established inspection and cleaning protocols to help ensure collection of representative data from monitoring systems unaffected by accumulated debris and sensor drift.

Following the *Standard Operating Procedure for Monitoring Station Maintenance* (WSDOT, 2015), field teams conducted equipment checks that included inspections, testing, and replacement of worn or missing parts. Monitoring staff inspected internal wires and cables to evaluate wear and ensure cable connections to the data loggers were in good condition. Staff checked station antennae declinations and bearings, and cleaned solar panels to remove accumulated debris. When servicing or calibrating scientific equipment at monitoring stations, trained staff and field technicians followed manufacturers' specifications and conducted servicing and calibration of equipment on site or in a controlled environment, as appropriate.

2.7 Equipment Decontamination

Unless certified as precleaned from the equipment source, a contract lab decontaminated churners, sample containers, and other materials that collected or conveyed sampled stormwater prior to each use. Monitoring field teams cleaned the intake pump head and intake

tubing prior to installation. Staff changed tubing at least once each year, or as necessary to address any contamination concerns.

For detailed descriptions of decontamination procedures, see the *Quality Assurance Project Plan WSDOT Roadway Stormwater Treatment Evaluation: Best Management Practices* (WSDOT 2021).

2.8 Quality Assurance and Quality Control

WSDOT implemented quality control procedures through all phases of data collection and analyses. Staff implemented quality control procedures during field data collection and laboratory processing for all samples. Additionally, verification of field- and laboratory-generated data occurred as part of an established data management and quality assurance program. The quality of raw, unprocessed and processed data were subject to review and management, including in the following:

1. Field quality control
    - Implementation of standard operating procedures.
    - Field instrument inspection, calibration, and maintenance.
    - Site water conveyance systems inspection and maintenance.
    - Collection of field notes and maintenance documentation.
    - Collection of composite field duplicate samples.
    - Collection of field equipment blanks.
2. Laboratory quality control
    - Laboratory instrument maintenance and calibration.
    - Analysis of laboratory duplicate/split samples.
    - Analysis of laboratory matrix spike and matrix spike duplicate samples.
    - Analysis of laboratory blanks and standards.
3. Data management
    - Implementation of standard operating procedures.
    - Hydrology and precipitation data verification.
    - Field data verification.
    - Correction of data gaps, anomalies, and use of qualification for precipitation and hydrology data.
    - Laboratory data verification.
    - Self-assessment and audit of project processes.

The *Quality Assurance Project Plan WSDOT Roadway Stormwater Treatment Evaluation: Best Management Practices* (WSDOT 2021) includes a comprehensive description of quality assurance and quality control activities.

3 Data Summaries and Analysis

This chapter presents a summary and analysis of the bioswale BMP data. WSDOT presents data for determining if the bioswale meets the basic treatment performance goals outlined in TAPE using data from the Vancouver and Mirrormont monitoring sites during the 2021-2024 monitoring period.

Influent to Effluent Pollutant Comparisons

A one-tailed Wilcoxon signed-rank test showed a statistically significant reduction in TSS concentrations after treatment ($p = 0.00036$). This result indicates that effluent TSS levels were consistently lower than influent levels across sampled storm events demonstrating effective pollutant removal by the Vancouver treatment system.

The Wilcoxon signed-rank test, a nonparametric alternative to the paired t-test, was used as it does not assume normally distributed data. A significance level of $\alpha = 0.05$ was applied. With a p-value well below this threshold, we conclude that the system significantly reduces TSS.

Table 5 Total Suspended Solids concentrations

Sample Date	Influent TSS (mg/L)	Effluent TSS (mg/L)
2/27/2022	32	0
4/30/2022	20	7
5/5/2022	25	11
5/14/2022	25	6
6/5/2022	25	8
11/1/2022	40	8
11/4/2022	31	7
3/13/2023	42	16
4/1/2023	12	0.01
10/25/2023	28	2
11/3/2023	29	2
12/3/2023	21	2
4/24/2024	81	17
5/22/2024	69	14
6/3/2024	5	0

Table 6 Total Suspended Solids percent concentration reduction

Sample Date	Influent TSS Concentration (mg/L) x Volume (L)	Effluent TSS Concentration (mg/L) x Volume (L)	% Reduction
2/27/2022	179386.1	0	100.0
4/30/2022	973040.1	39419.8	95.9
5/5/2022	827793.8	35774.2	95.7
5/14/2022	788226.8	24703.2	96.9
6/5/2022	340441.0	8473.6	97.5
11/1/2022	3269793.3	29607.2	99.1
11/4/2022	4027938.6	83201.79	97.9
3/13/2023	5442553.2	228943.84	95.8
4/1/2023	343448.9	44.933	100.0
10/25/2023	840247.9	6404.8	99.2
11/3/2023	1827972.7	9551.8	99.5
12/3/2023	1177658.6	23632.2	98.0
4/24/2024	6015300.2	124446.8	97.9
5/22/2024	1670775.9	36145.2	97.8
6/3/2024	435068.7	0	100.0

Statistical Evaluation of Performance Goals

The treatment system achieved a TSS removal efficiency of 97%. This exceeds the TAPE performance goal of 80%, providing strong evidence that the system consistently meets or surpasses required treatment standards.

Table 7 Removal efficiency

Effluent Concentration (mg/L)	Removal Efficiency (%)
0	100
7	96
11	96
6	97
8	98
8	99
7	98
16	96
0.01	100
2	99
2	99
2	100
17	98
14	98
0	100

Pollutant removal as a function of flow rate

This analysis investigated the linear relationship between pollutant removal efficiency and effluent flow rate. A linear regression model was applied to assess how variations in flow rate correspond to changes in pollutant removal performance.

The linear regression model yielded a coefficient of determination R-squared value of 0.009. This indicates that only 0.9% of the variability observed in pollutant removal efficiency can be statistically explained by the effluent flow rate. Furthermore, the p-value for the effluent flow rate coefficient was 0.743. As this p-value is considerably greater than the conventional significance level of 0.05, it demonstrates that the observed relationship between effluent flow rate and pollutant removal efficiency is not statistically significant.

Outlier Analysis

Interquartile Range

An interquartile range (IQR) analysis was performed to identify potential outliers in the dataset.

Since stormwater science often displays high variability through pulses of very high or very low pollutant concentrations and differing stormwater volumes three times the IQR was used to recognize outliers.

Effluent TSS Concentration				
1st quartile	3rd quartile	IQR	Lower bound	Upper bound
2	9.5	7.5	-20.5	32

Effluent 90th Percentile Flow Rate				
1st quartile	3rd quartile	IQR	Lower bound	Upper bound
1.5	3.2	1.7	-3.6	8.4

Coefficient of Variation Analysis

A coefficient of variation (CV) of 0.87 was calculated for the effluent suggesting that TSS values are dispersed around the mean. Flow rate CV was calculated as 0.48, indicating a more stable pattern.

Visual Inspection

Visual inspection of the scatter plot below (Figure 11) indicated no extreme outliers that unduly influenced the regression relationship.

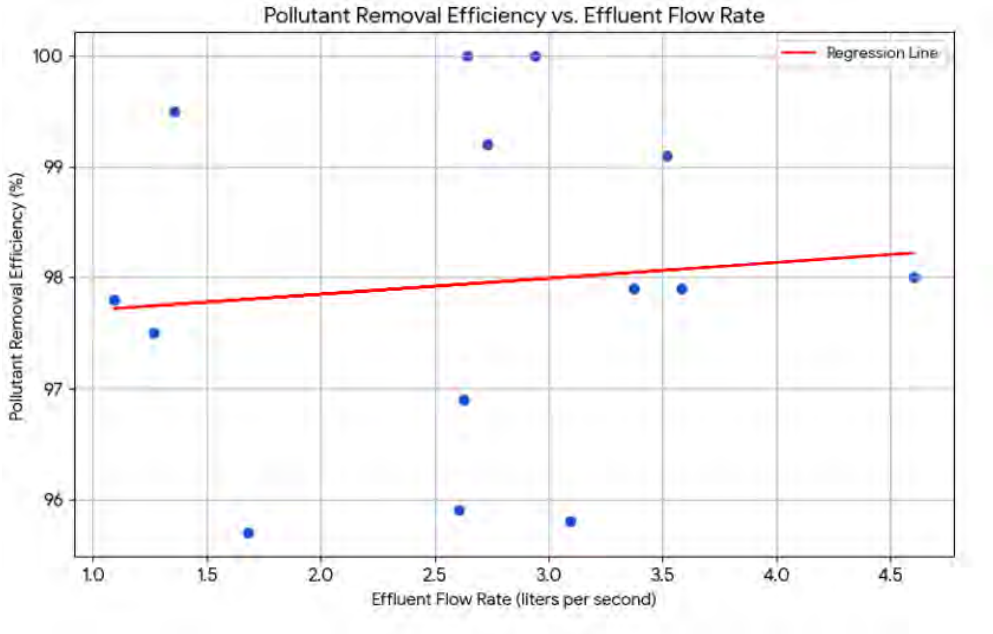

Figure 11 Pollutant Removal Efficiency vs. Effluent Flow Rate

Linearity

To evaluate whether a linear model appropriately describes the relationship between flow rate and TSS removal efficiency, both visual inspection and statistical testing were conducted.

A scatter plot of removal efficiency versus flow rate indicated a generally linear trend, without strong curvature or non-linear patterns. To formally assess this, the Global Validation of Linear Model Assumptions test was applied. The test returned a p-value of 0.3161, indicating no significant evidence of non-linearity in the model.

Constant Variance (Homoscedasticity)

To evaluate whether the assumption of constant variance holds in the linear regression model, a Breusch-Pagan test was performed. This test assesses whether the variance of the residuals is dependent on the values of the independent variable.

The test yielded a p-value of 0.5488, which is well above the standard significance threshold of 0.05. This indicates that there is no evidence of heteroscedasticity, and the assumption of homoscedasticity is satisfied as the data points were evenly scattered around the regression line.

4 Discussion

4.1 BMP Hydraulic Performance

Both BMPs displayed statistically significant stormwater volume reduction, presumably due to infiltration. The one-tailed Wilcoxon signed-rank tests, assessing if influent volumes were greater than effluent volumes, exhibited p-value of p = 0.00036.

The BMP stormwater influent volumes ranged from 1,554.8 to 40,477.9 gallons. Effluent volumes ranged from 874.2 to 14,566 gallons. WSDOT only utilized sampled, hydrologically validated storm events for influent to effluent volume comparisons.

The BMPs displayed the following volume reductions:

- Vancouver Bioswale - 57.6 percent reduction.
- Mirrormont Bioswale - 92.75 percent reduction.

These high-volume reductions were the primary factor in reducing stormwater mass pollutant loads. Overall, the bioswales are predominately infiltration BMPs with secondary stormwater treatment capabilities.

4.2 TSS Results

The Vancouver swale displayed statistically significant TSS concentration reduction.

The BMP displayed differences in TSS concentration reduction as follows:

- Vancouver Bioswale - 81 percent reduction.

The Vancouver bioswale exhibited strong total TSS pollutant removal efficiency, based on the combination of reduced runoff volumes and reduced TSS concentrations. The swale met TAPE basic treatment guidelines of 80 percent total TSS pollutant removal efficiency.

The BMP displayed differences in TSS pollutant removal efficiency as follows:

- Vancouver Bioswale of 97.453% percent pollutant removal efficiency.

The TSS influent values ranged from 5 mg/L to 81 mg/L. The Vancouver Bioswale displayed a mean influent of 32.33 mg/L and median influent of 28 mg/L.

TSS samples were not collected at the Mirrormont swale. WSDOT targeted 62 storm events for sampling but was unable capture a paired sample. The length of the swale and the large collection area created very short intense runoff events. These events produced runoff at the effluent sample location of too short duration for the auto sampler to properly collect flow-weighted aliquots.

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Appendix A: Storm Reports

Download 22 Vancouver

Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.30	02/27/2022 00:20	02/27/2022 16:35	16.25	53.25

Aliquots							Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	7	02/27/2022 01:05	02/27/2022 11:35	10.50	250	1,750	5.40	7.10

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	02/27/2022 00:25	02/27/2022 17:05	16.67	1,554.8	93.3	1,554.8	1,480.9	95.20	10.95	0.01	1.98	0.130	

No comments added for this event

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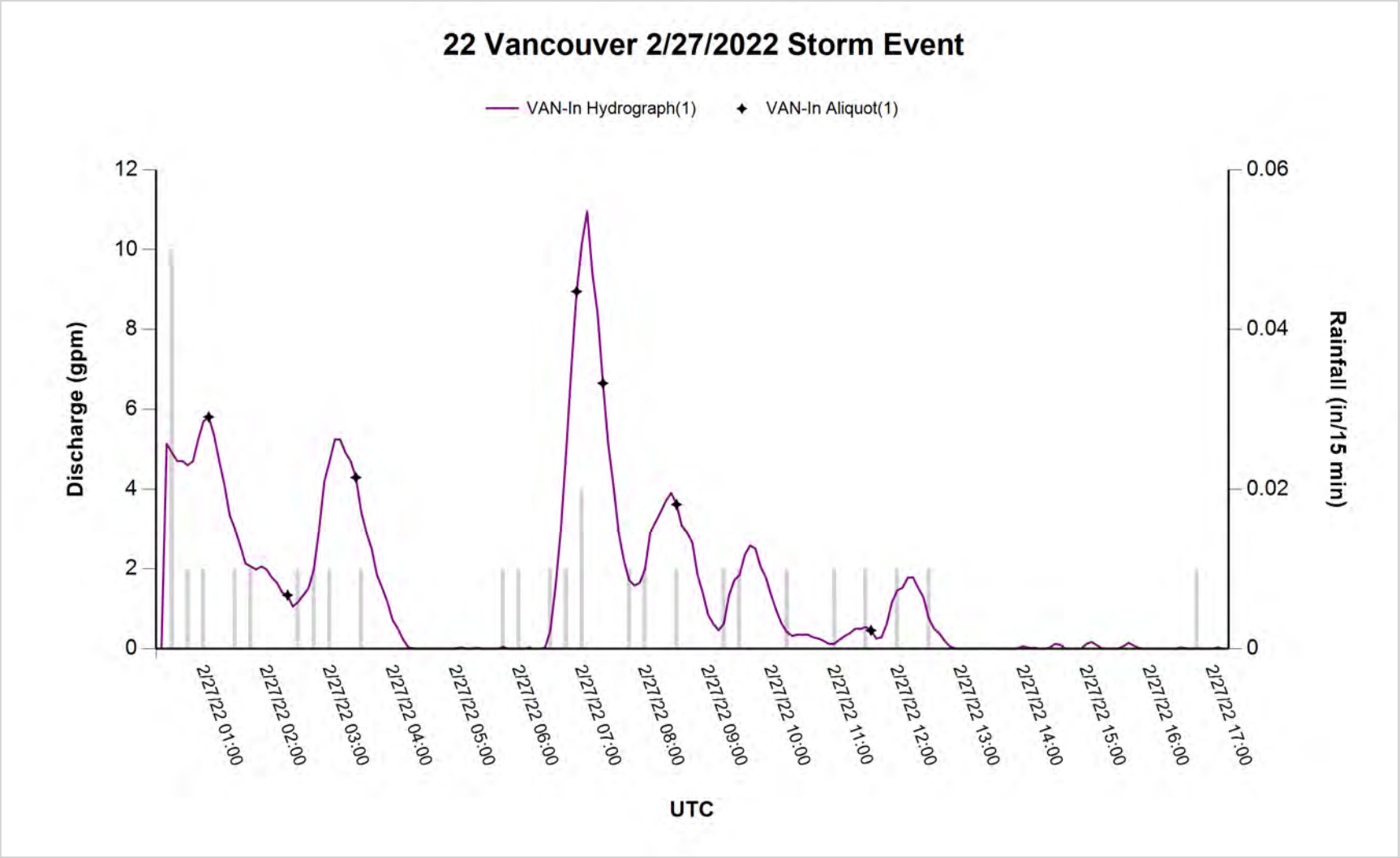
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.39	04/18/2022 19:05	04/19/2022 00:10	5.08	1507.58

Aliquots								Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	15	04/18/2022 19:30	04/19/2022 00:20	4.83	250	3,750	11.20	12.10
2	VAN-Out	5	04/18/2022 22:45	04/18/2022 23:35	0.83	250	1,250	11.30	11.70

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	04/18/2022 19:10	04/19/2022 05:05	9.92	7,348.6	740.8	7,348.6	7,182.0	97.70	75.64	0.04	12.25	0.337	
2	VAN-Out	04/18/2022 20:05	04/19/2022 00:00	3.92	1,391.0	354.9	1,391.0	1,344.9	96.70	34.00	0.13	9.27	0.187	

No comments added for this event

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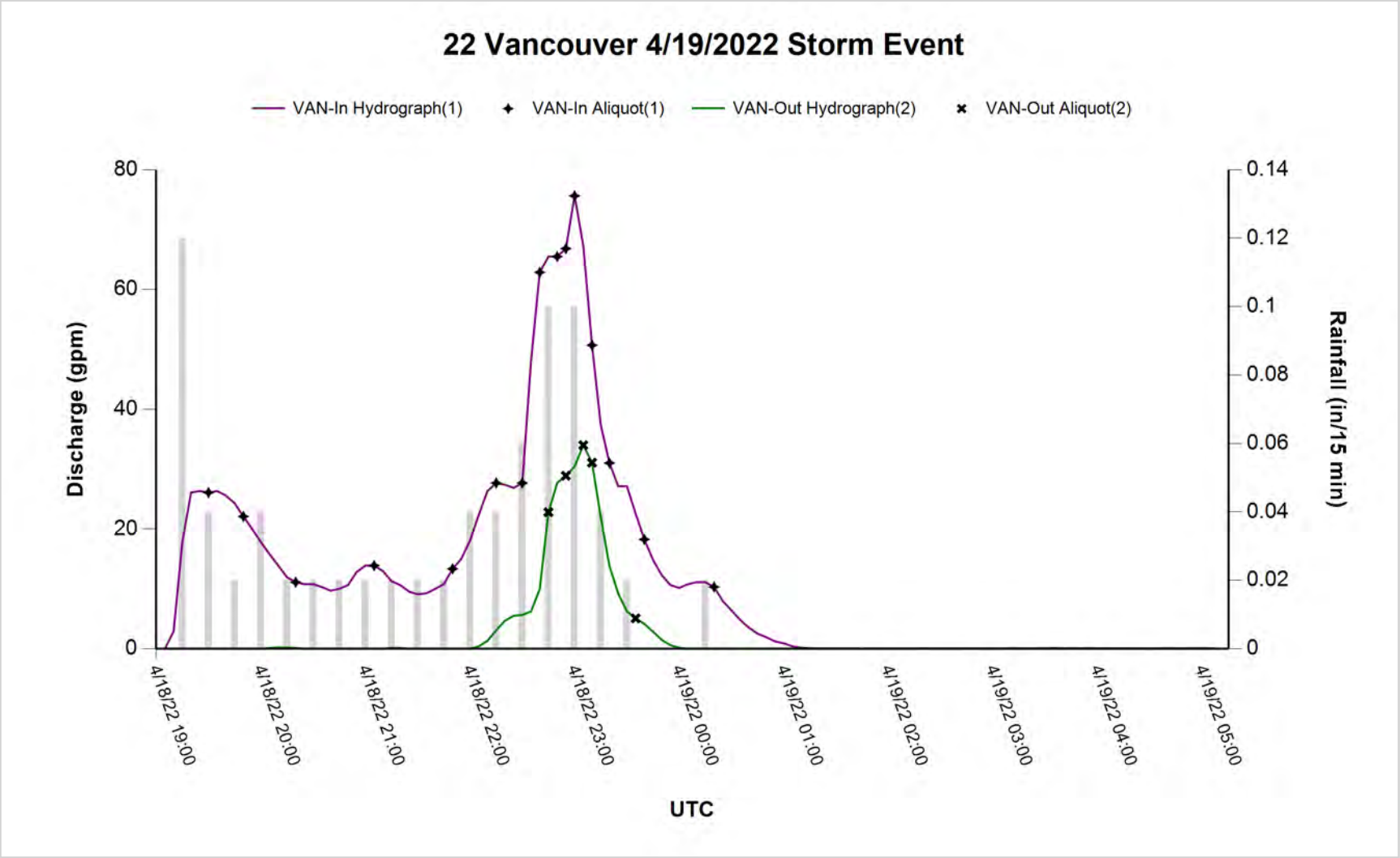
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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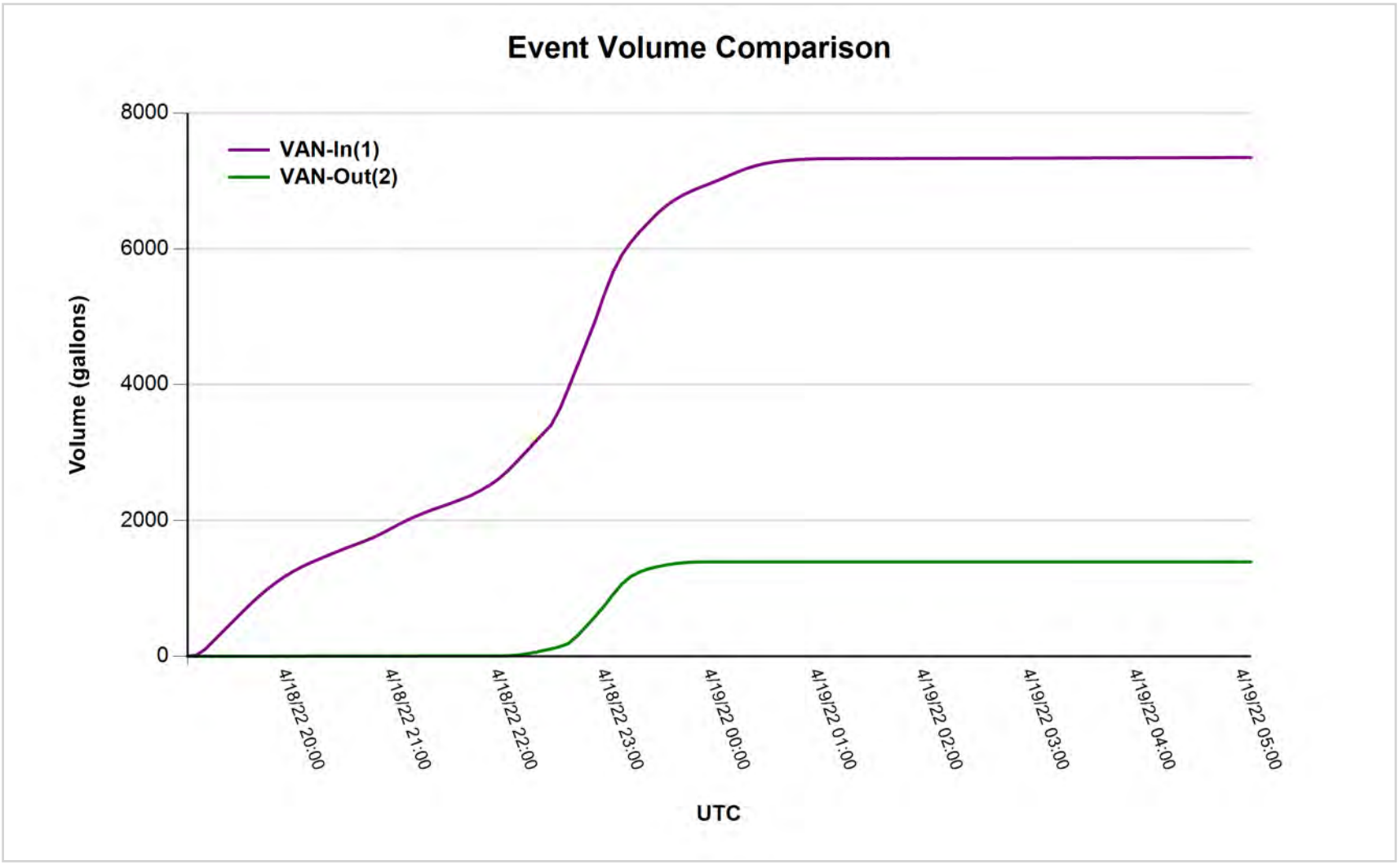
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.76	04/30/2022 03:40	04/30/2022 13:45	10.08	16.66

Aliquots							Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	27	04/30/2022 04:00	04/30/2022 13:50	9.83	250	6,750	11.40	13.50
2	VAN-Out	21	04/30/2022 04:35	04/30/2022 16:50	12.25	250	5,250	11.40	14.50

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	04/30/2022 03:45	04/30/2022 17:20	13.58	12,909.5	950.6	12,909.5	12,852.5	99.60	63.31	0.01	17.81	0.310	
2	VAN-Out	04/30/2022 03:45	04/30/2022 18:55	15.17	5,631.4	371.2	5,631.4	5,549.0	98.50	42.82	0.13	6.74	0.212	

No comments added for this event

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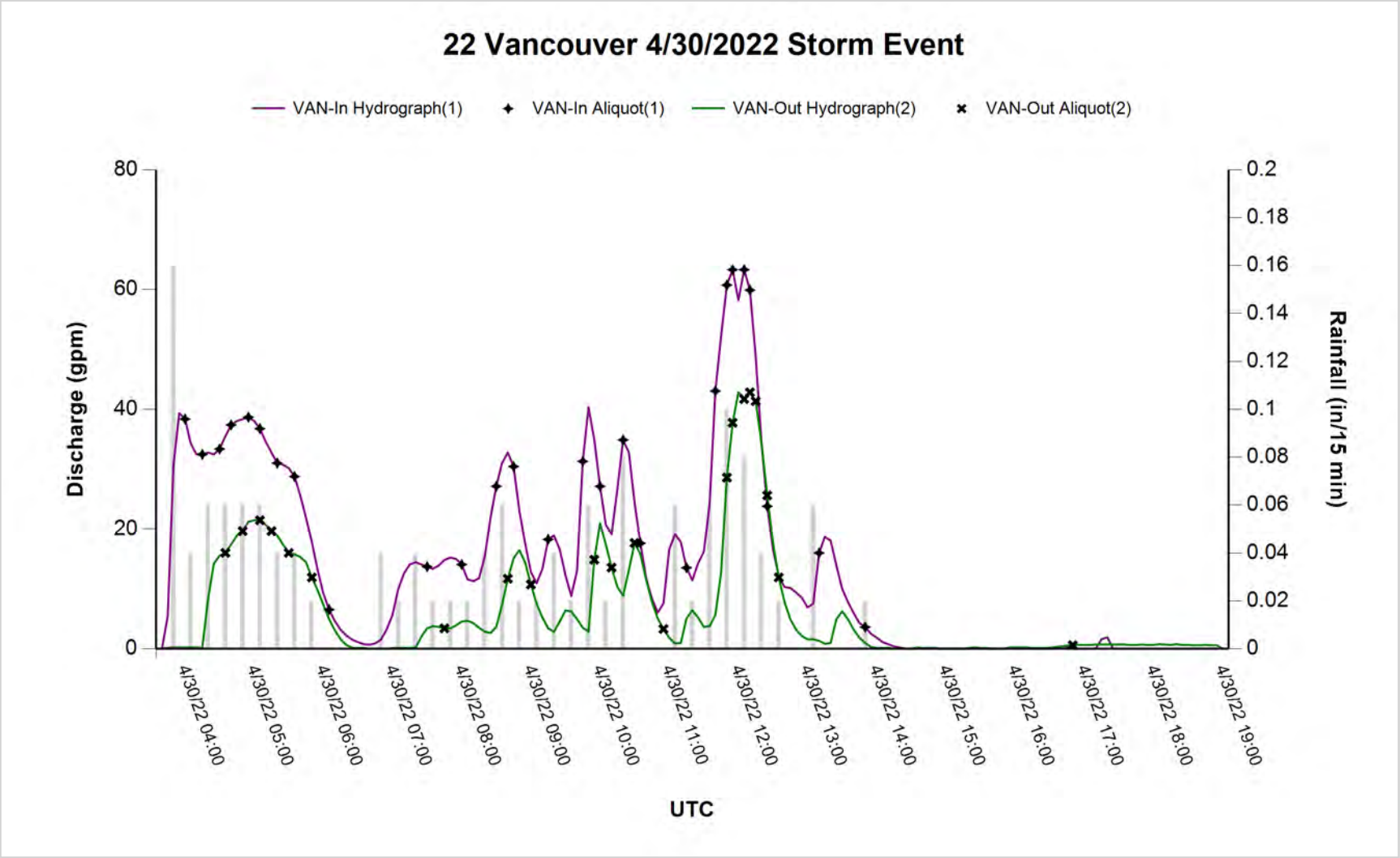
Drainage Area (acres):



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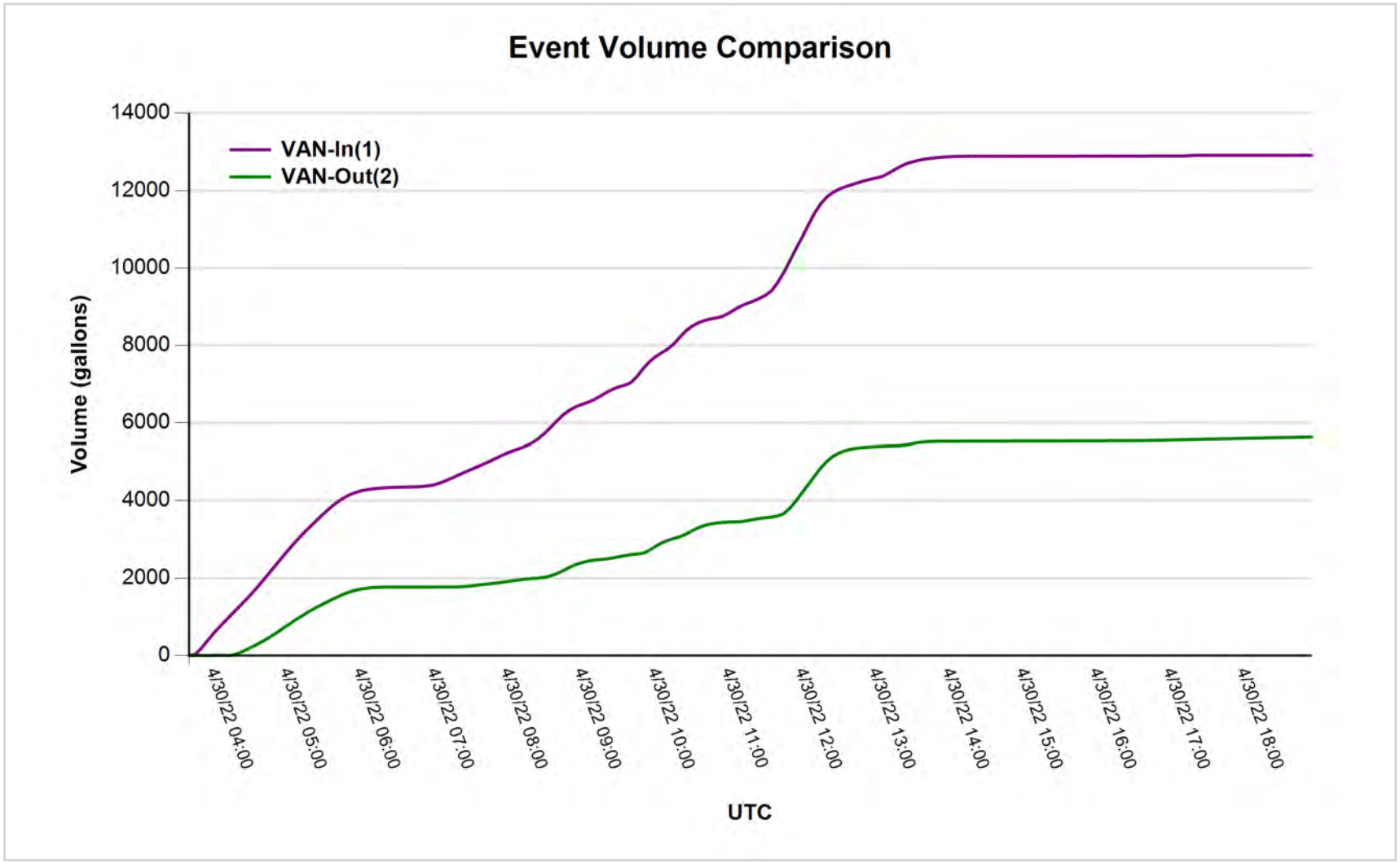
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.57	05/05/2022 13:55	05/05/2022 23:50	9.92	2.16

Aliquots								Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	15	05/05/2022 14:40	05/05/2022 21:30	6.83	250	3,750	12.30	14.70
2	VAN-Out	9	05/05/2022 15:25	05/05/2022 21:30	6.08	250	2,250	12.30	14.70

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	05/05/2022 14:00	05/06/2022 02:50	12.83	8,855.9	690.3	8,855.9	8,747.2	98.80	54.18	0.01	14.28	0.288	
2	VAN-Out	05/05/2022 14:00	05/06/2022 02:55	12.92	3,452.0	267.2	3,452.0	3,352.2	97.10	33.01	0.13	6.84	0.184	

No comments added for this event

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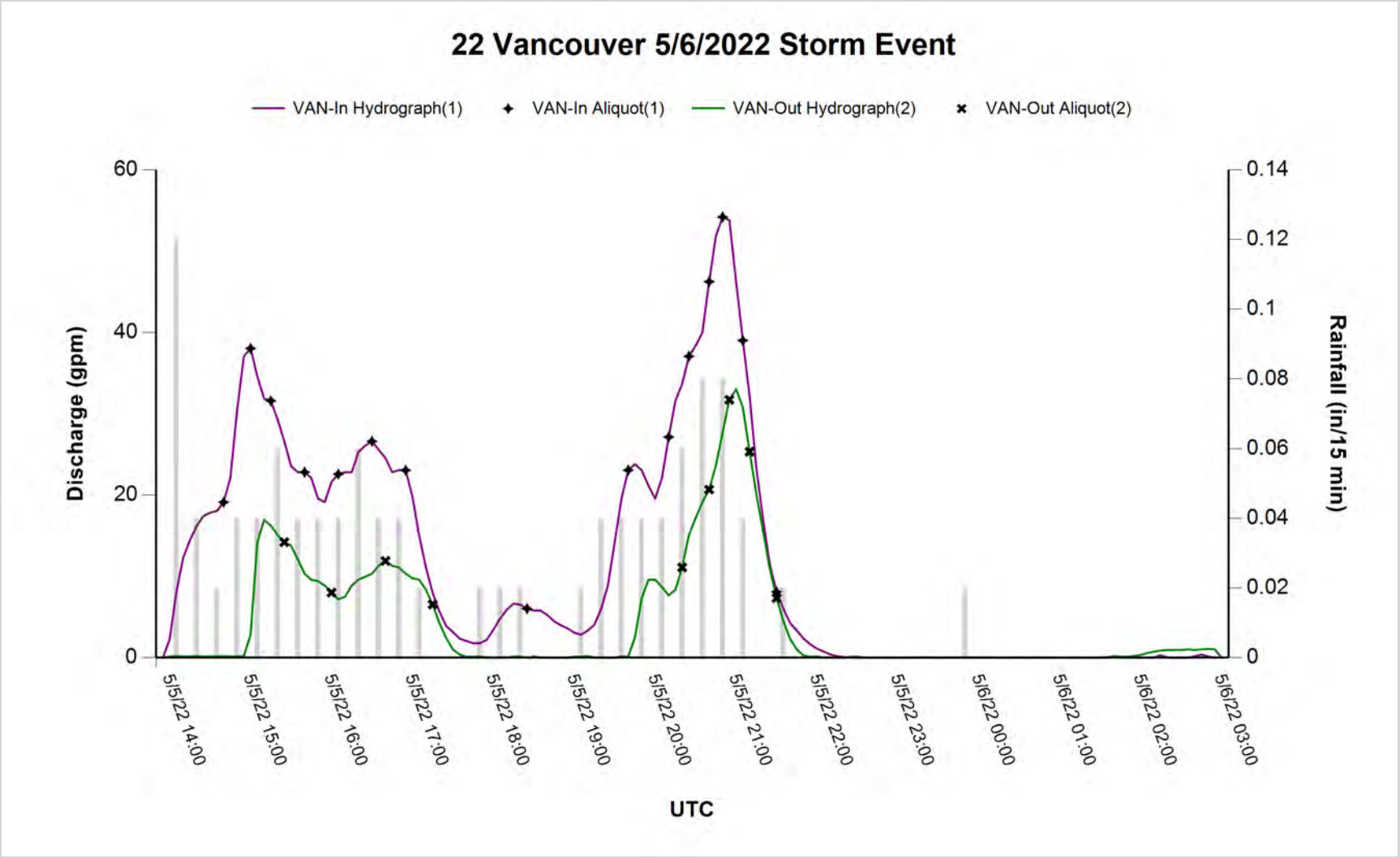
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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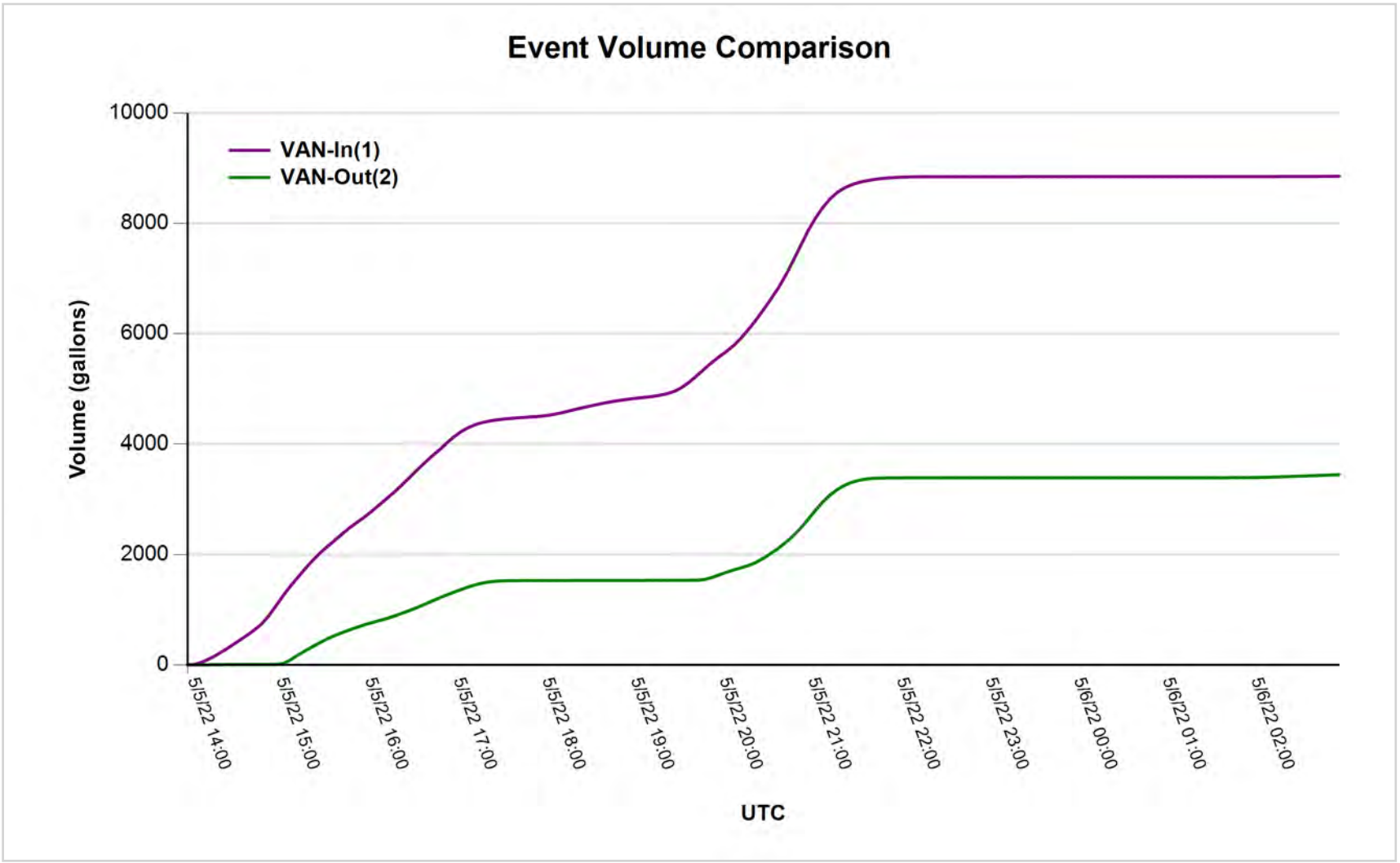
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.77	05/14/2022 02:15	05/14/2022 16:40	14.42	28.66

Aliquots								Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	21	05/14/2022 03:00	05/14/2022 16:05	13.08	250	5,250	11.40	13.40
2	VAN-Out	19	05/14/2022 04:15	05/14/2022 16:00	11.75	250	4,750	11.40	12.80

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	05/14/2022 02:20	05/14/2022 19:50	17.50	8,344.6	476.8	8,344.6	8,329.1	99.80	69.08	0.01	11.67	0.323	
2	VAN-Out	05/14/2022 02:20	05/14/2022 21:15	18.92	4,117.2	217.6	4,117.2	4,021.1	97.70	46.25	0.13	4.48	0.221	

No comments added for this event

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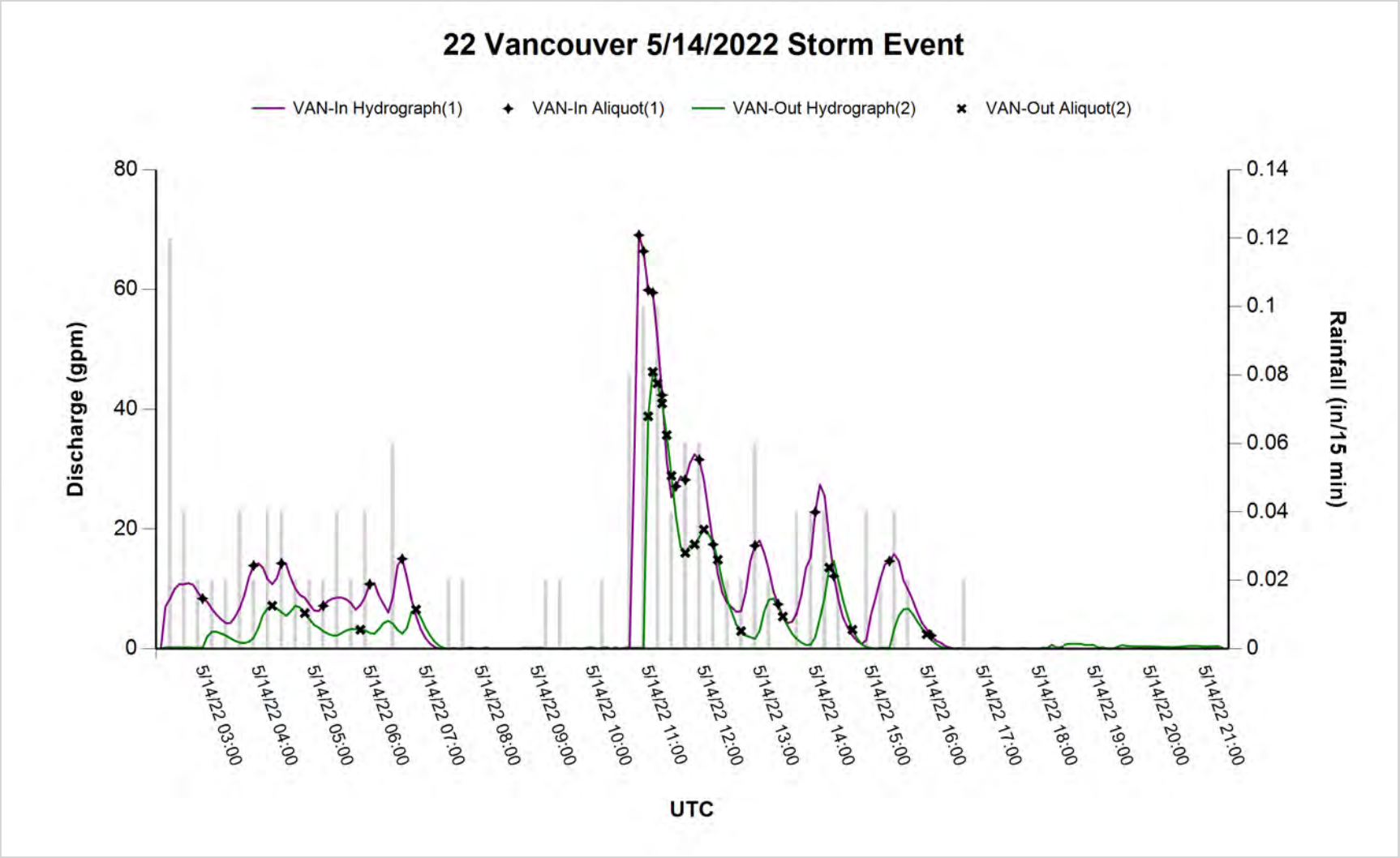
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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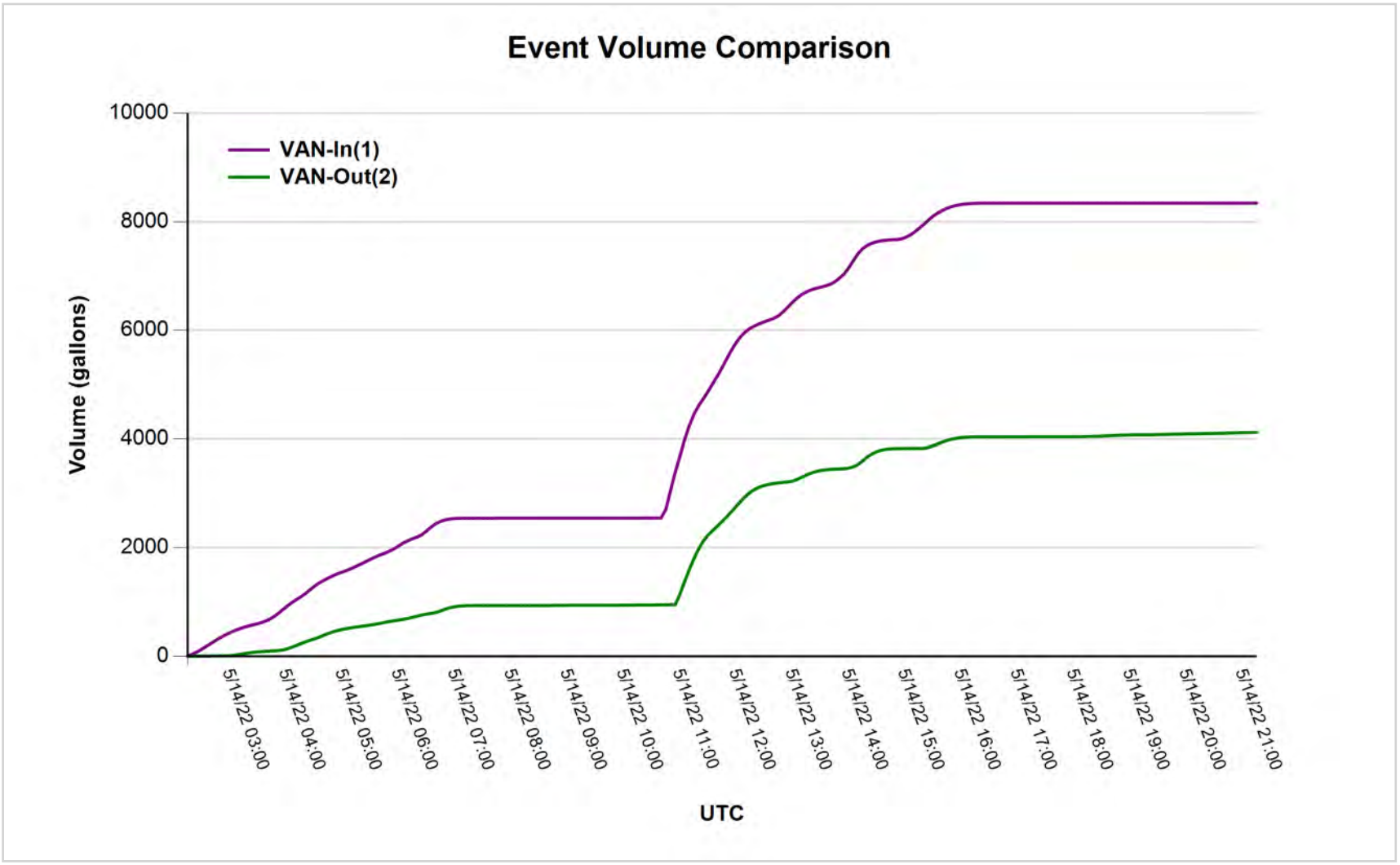
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.49	06/04/2022 20:15	06/05/2022 12:00	15.75	2106.16

Aliquots								Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	8	06/05/2022 01:40	06/05/2022 09:30	7.83	250	2,000	16.40	18.50
2	VAN-Out	4	06/05/2022 02:25	06/05/2022 07:05	4.67	250	1,000	16.70	18.20

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	06/04/2022 20:45	06/05/2022 11:30	14.75	3,861.3	261.8	3,861.3	3,597.4	93.20	44.10	0.01	6.13	0.261	
2	VAN-Out	06/05/2022 01:45	06/05/2022 12:05	10.33	1,075.7	104.1	1,075.7	1,059.2	98.50	22.54	0.13	3.65	0.149	

No comments added for this event

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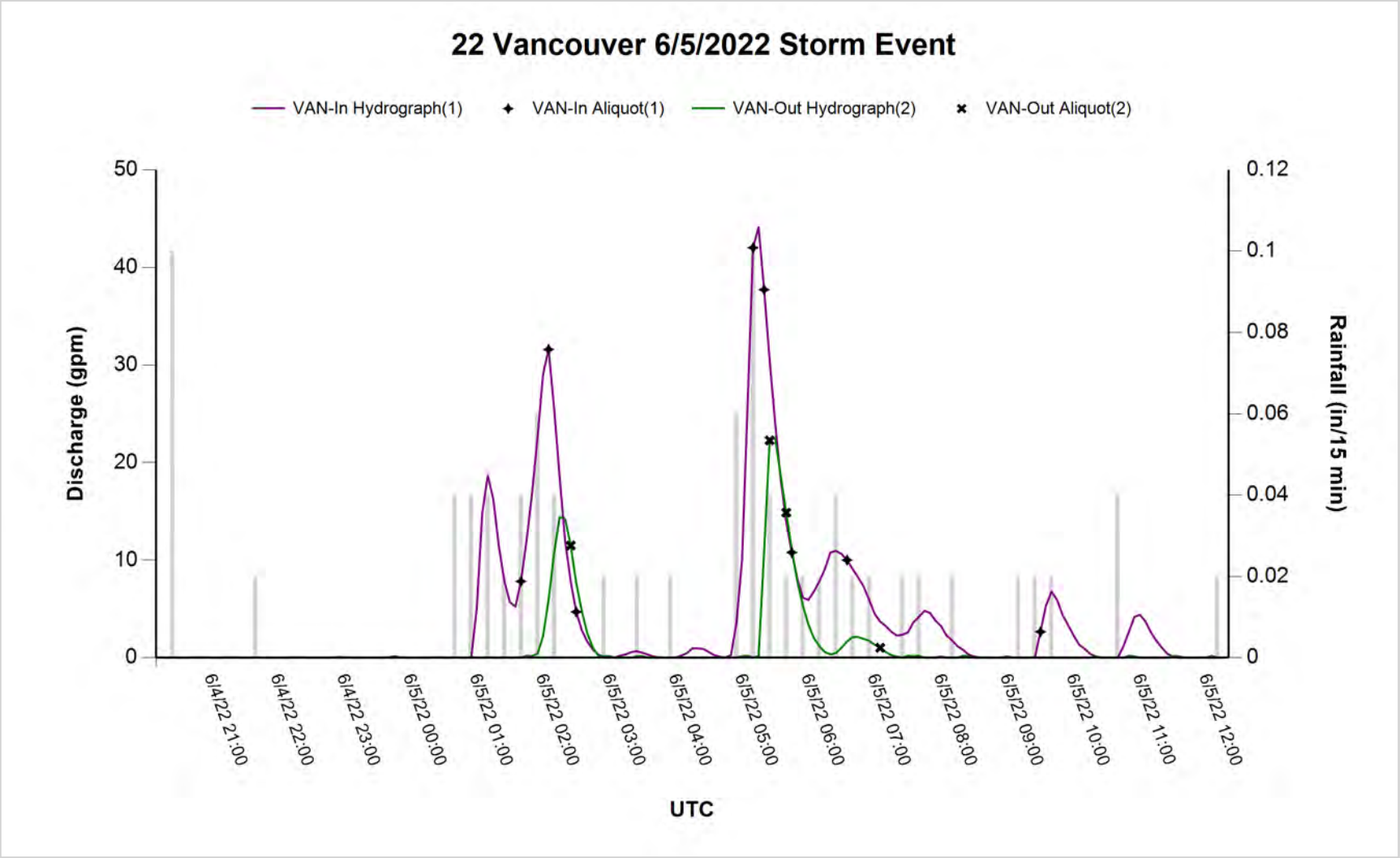
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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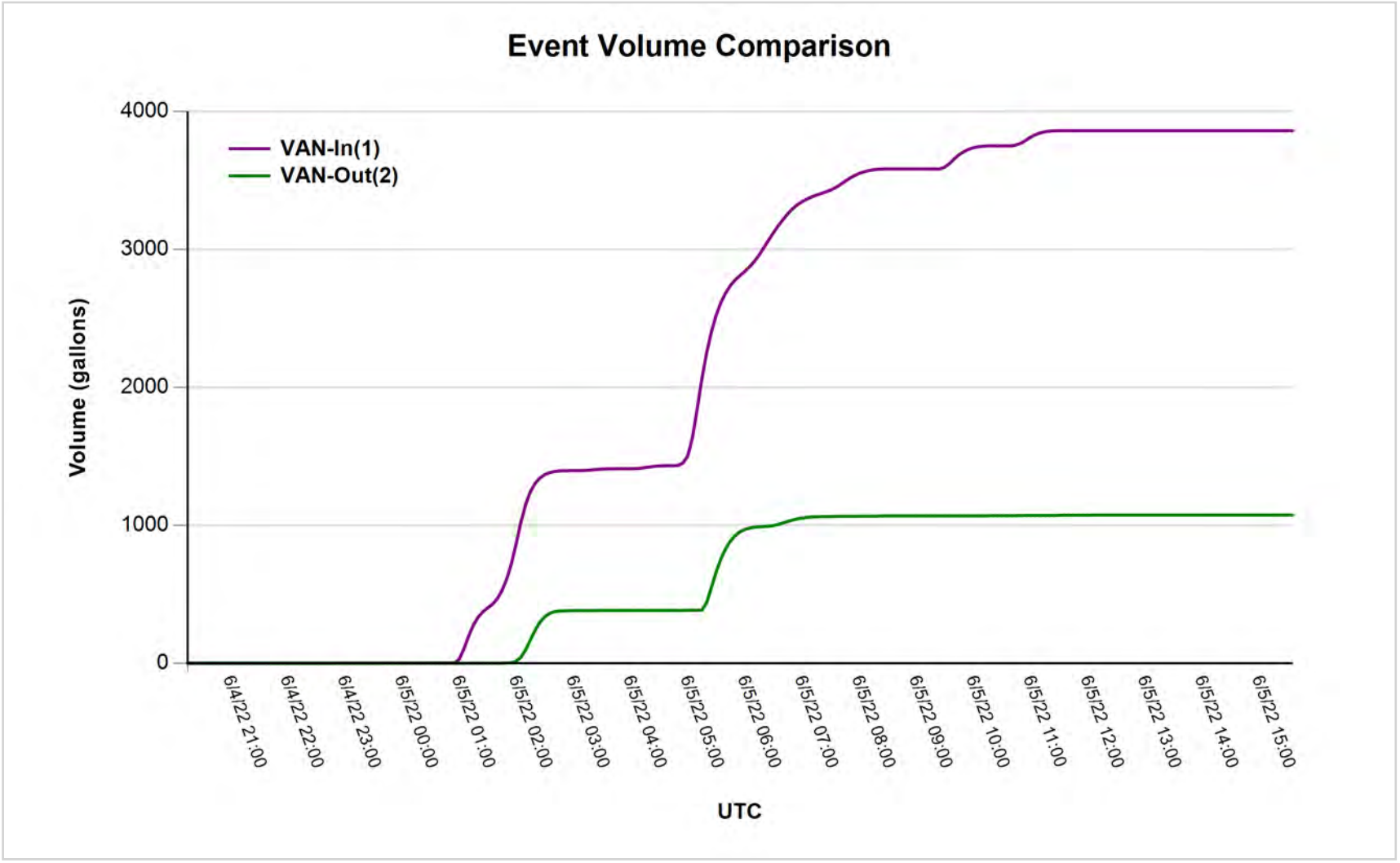
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.63	06/10/2022 00:50	06/10/2022 11:35	10.75	56.58

Aliquots							Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	21	06/10/2022 02:20	06/10/2022 11:20	9.00	250	5,250	17.70	19.70
2	VAN-Out	15	06/10/2022 02:45	06/10/2022 10:55	8.17	250	3,750	17.80	19.50

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	06/10/2022 02:10	06/10/2022 12:20	10.17	8,514.6	837.2	8,514.6	8,341.4	98.00	126.42	0.01	17.56	0.427	
2	VAN-Out	06/10/2022 02:05	06/10/2022 16:50	14.75	3,298.0	223.6	3,298.0	3,178.0	96.40	85.01	0.13	8.91	0.305	

No comments added for this event

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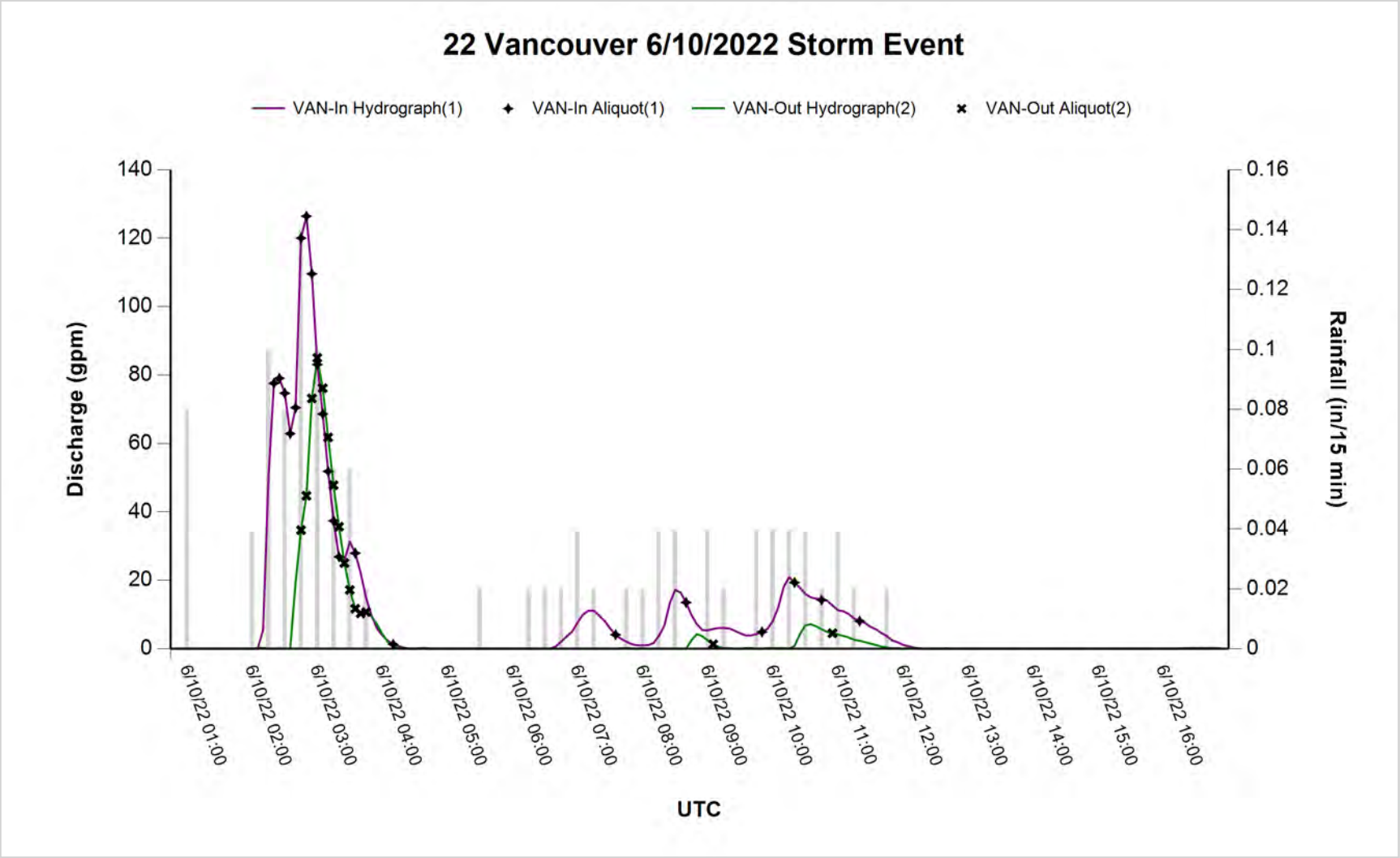
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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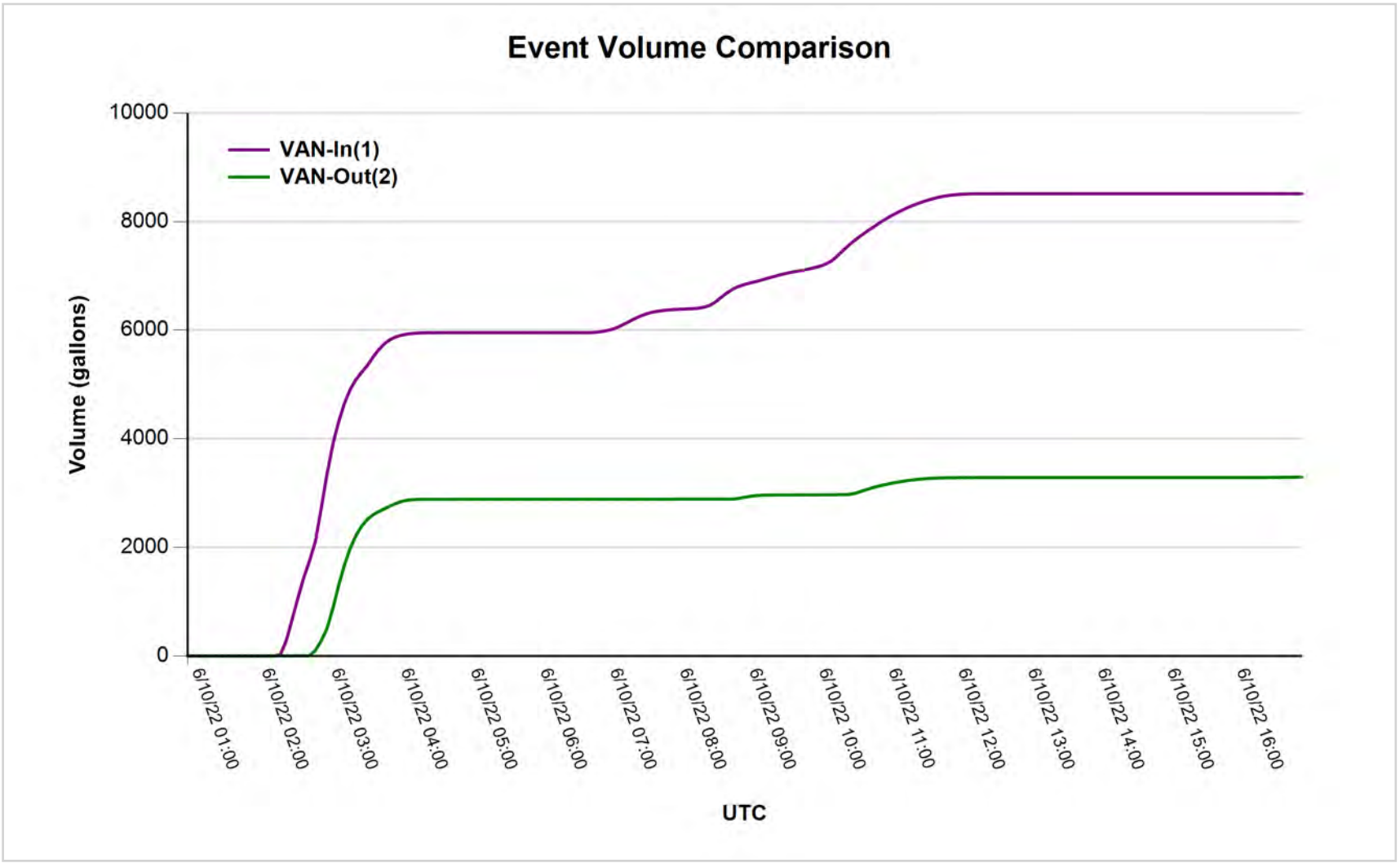
Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.46	10/21/2022 19:50	10/22/2022 08:05	12.25	3.91

Aliquots								Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	23	10/21/2022 21:45	10/22/2022 05:20	7.58	250	5,750	11.10	15.10
2	VAN-Out	4	10/22/2022 04:50	10/22/2022 05:10	0.33	250	1,000	11.10	11.30

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	10/21/2022 19:55	10/22/2022 10:35	14.67	10,555.1	719.5	10,555.1	10,396.1	98.50	518.12	0.06	11.93	0.500	
2	VAN-Out	10/21/2022 19:55	10/22/2022 10:35	14.67	874.2	59.6	874.2	755.2	86.40	35.01	0.13	1.07	0.190	

No comments added for this event

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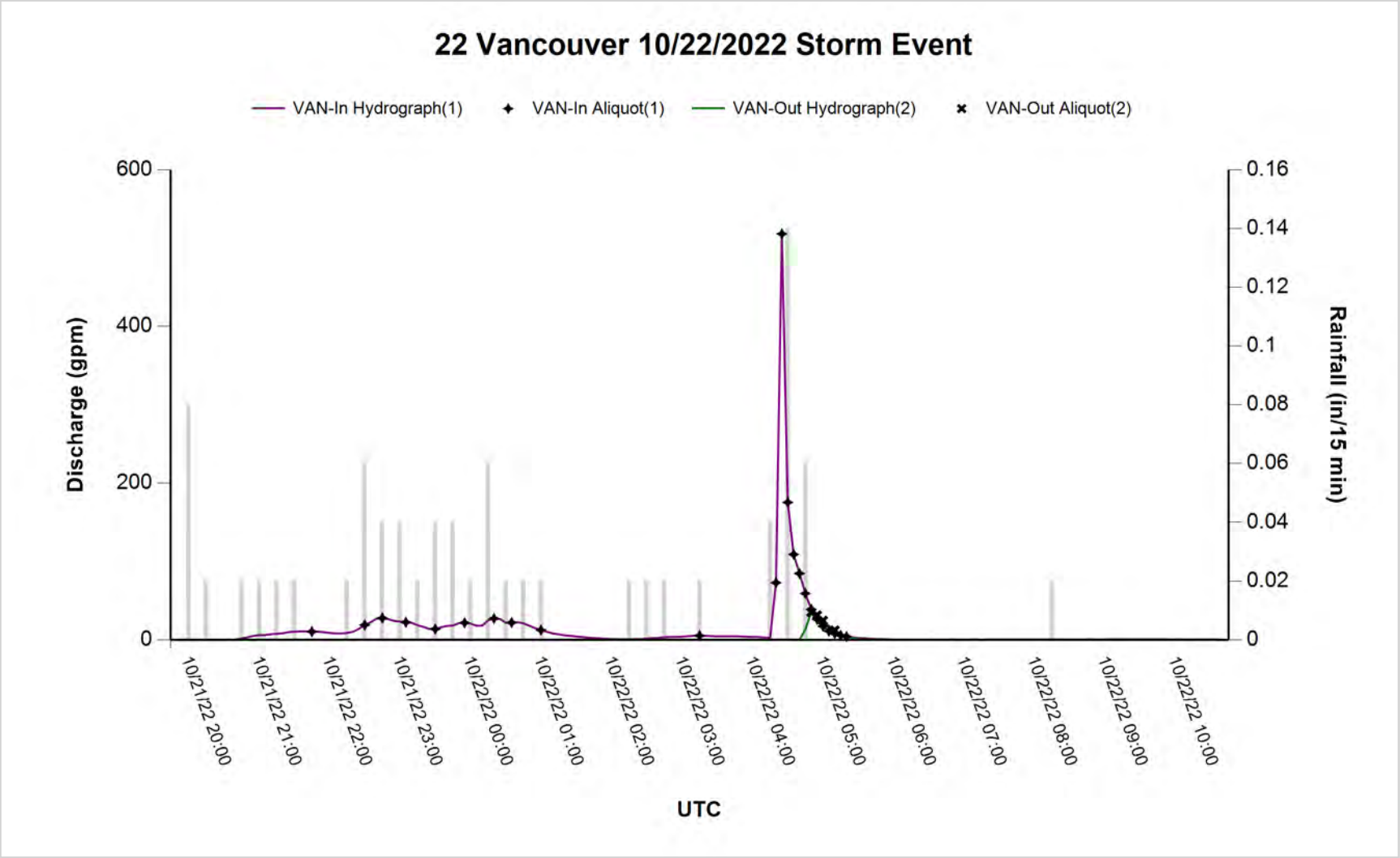
Drainage Area (acres):



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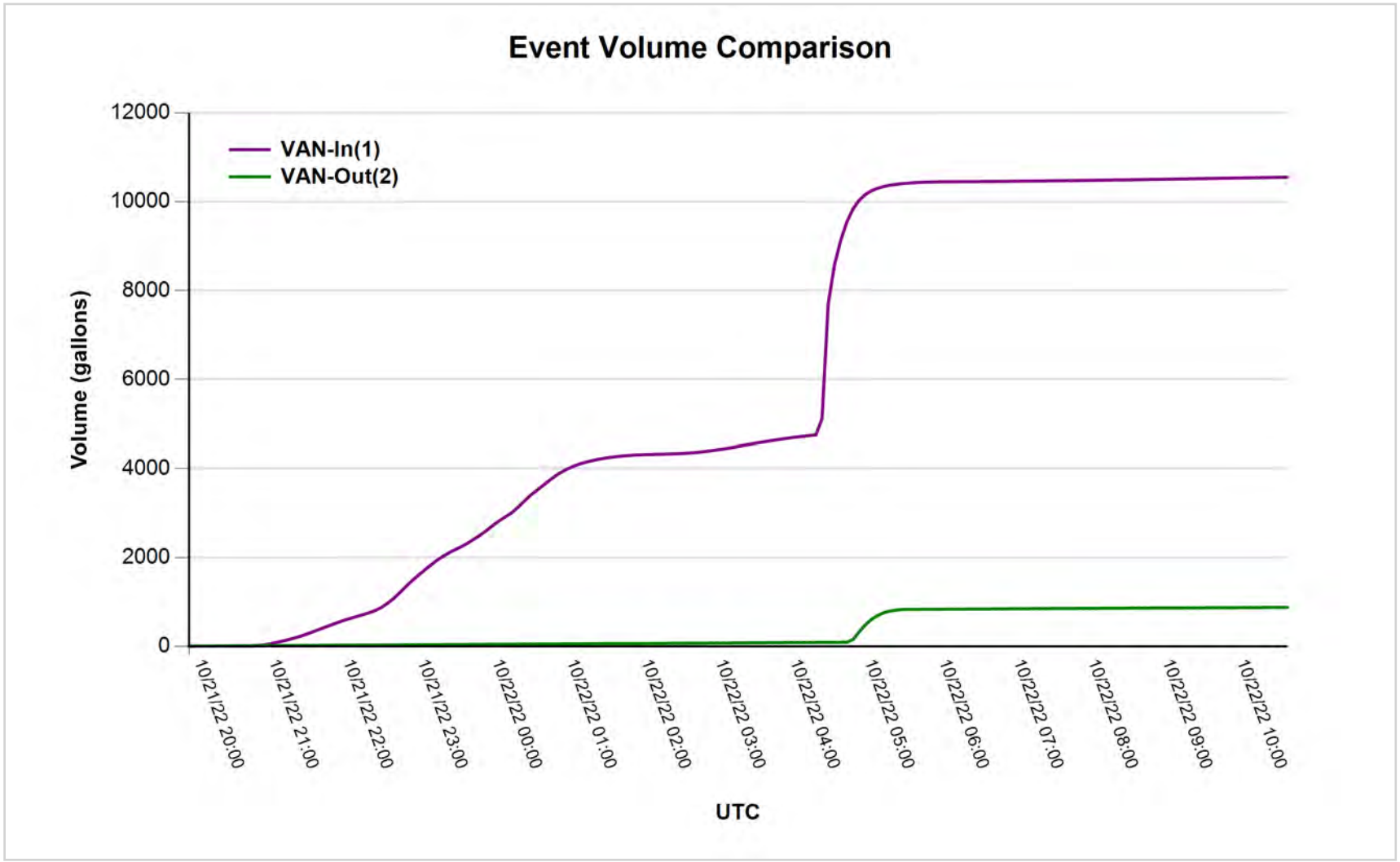
Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.54	10/28/2022 15:15	10/29/2022 04:30	13.25	4971.16

Aliquots								Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	21	10/28/2022 15:40	10/29/2022 04:05	12.42	250	5,250	11.80	13.90
2	VAN-Out	6	10/28/2022 17:45	10/28/2022 23:05	5.33	250	1,500	12.10	13.80

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	10/28/2022 15:20	10/29/2022 08:10	16.83	11,388.6	676.7	11,388.6	11,126.7	97.70	58.22	0.12	11.22	0.298	
2	VAN-Out	10/28/2022 15:20	10/29/2022 08:10	16.83	1,264.5	75.1	1,264.5	1,137.7	90.00	17.18	0.13	1.60	0.128	

No comments added for this event

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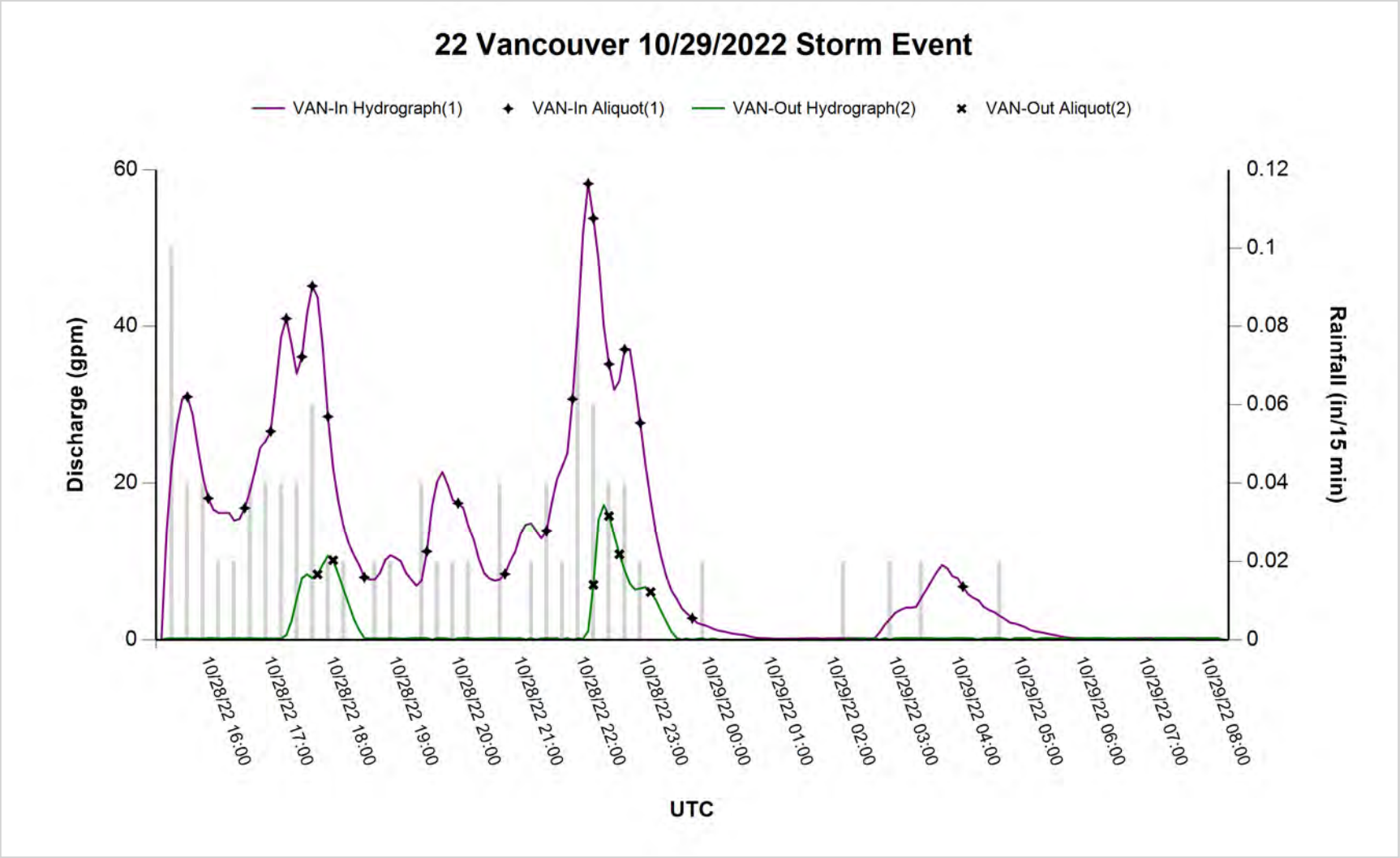
Drainage Area (acres):



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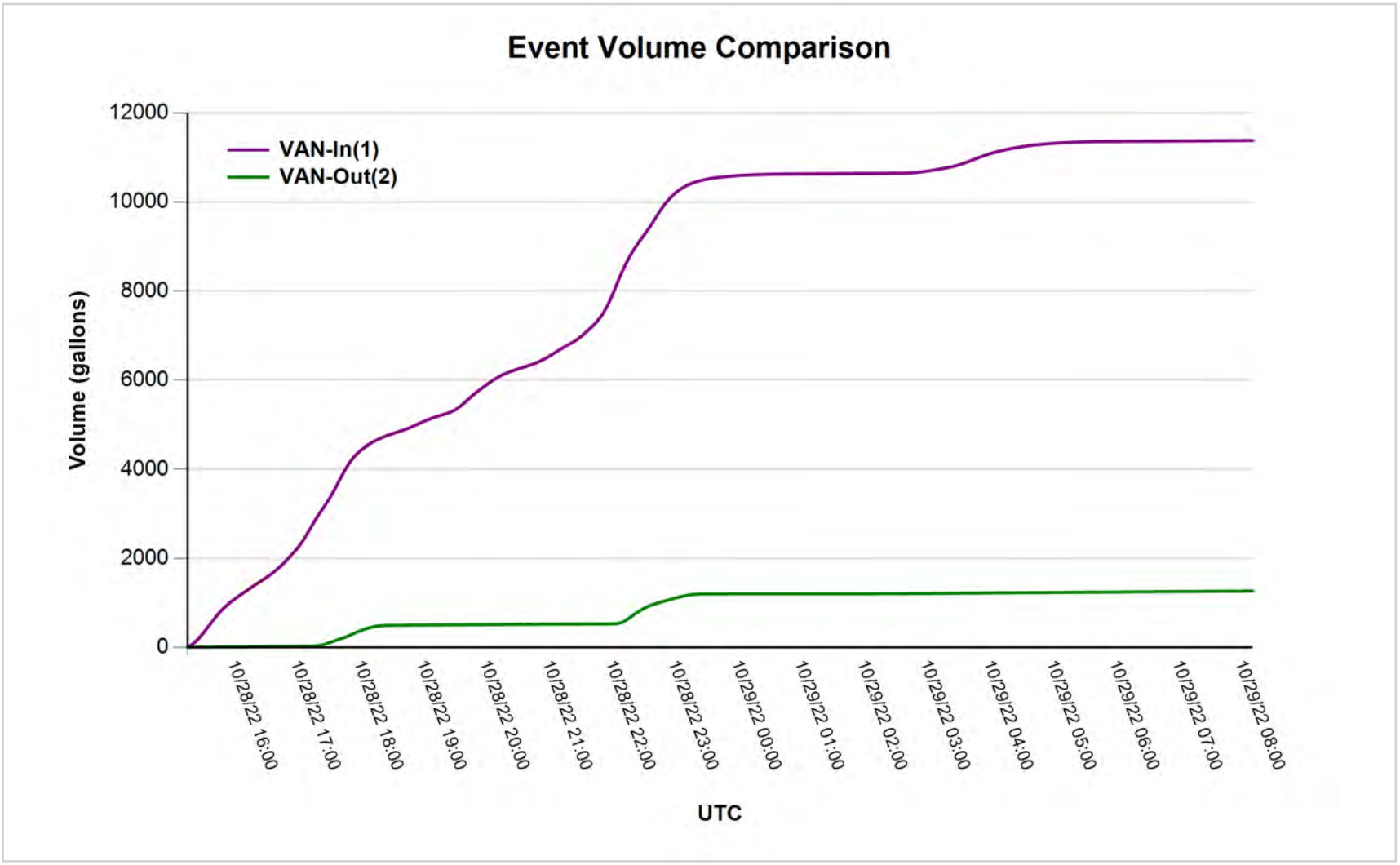
Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.72	10/31/2022 13:45	11/01/2022 15:30	25.75	48.58

Aliquots							Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	31	10/31/2022 14:05	11/01/2022 10:55	20.83	250	7,750	10.30	14.30
2	VAN-Out	20	10/31/2022 15:50	11/01/2022 10:35	18.75	250	5,000	10.30	14.30

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	10/31/2022 13:50	11/01/2022 15:55	26.08	21,594.7	828.0	21,594.7	21,312.4	98.70	245.38	0.14	13.75	0.500	
2	VAN-Out	10/31/2022 13:50	11/01/2022 15:50	26.00	3,763.7	144.8	3,763.7	3,700.9	98.30	151.93	0.13	3.36	0.410	

No comments added for this event

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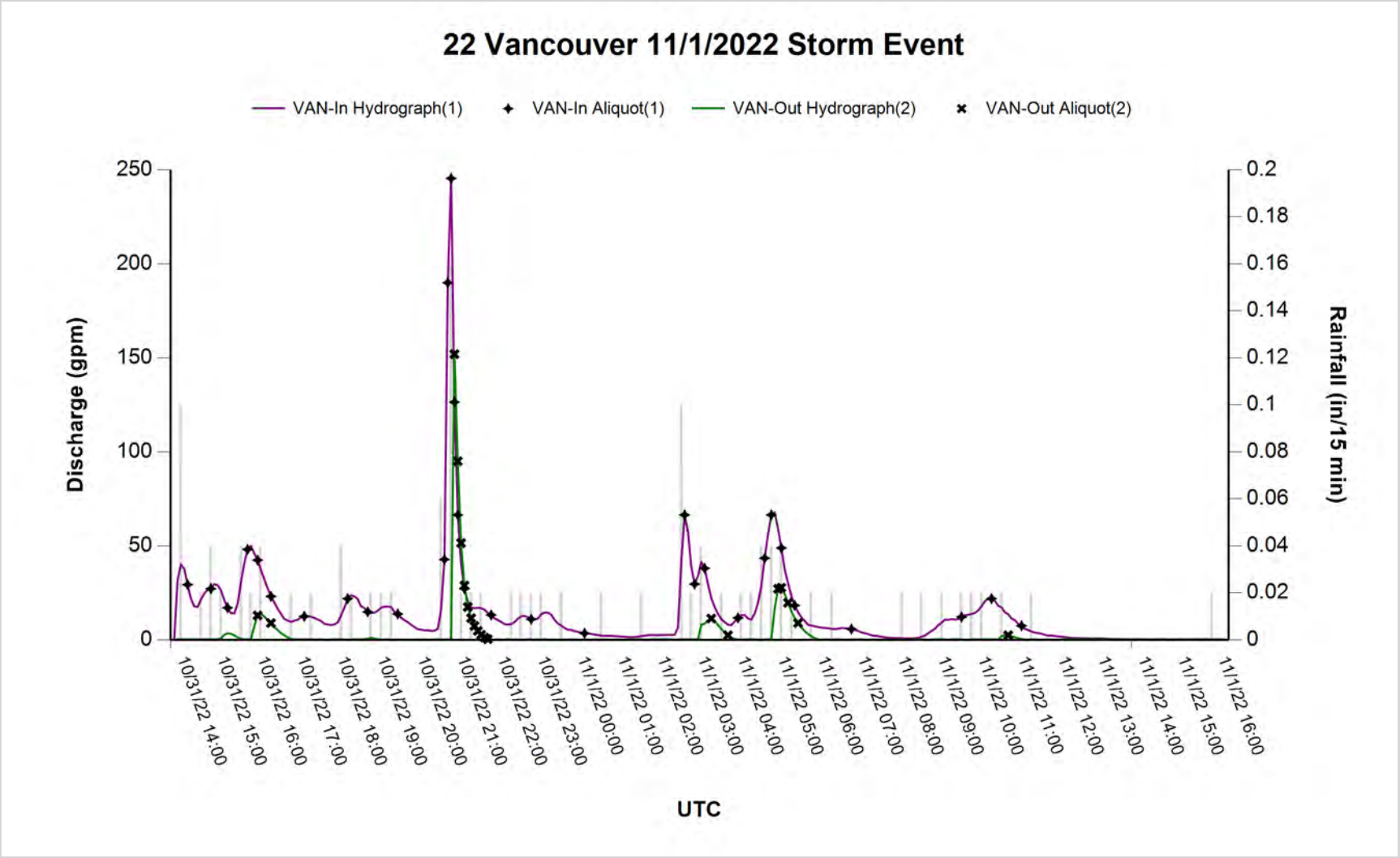
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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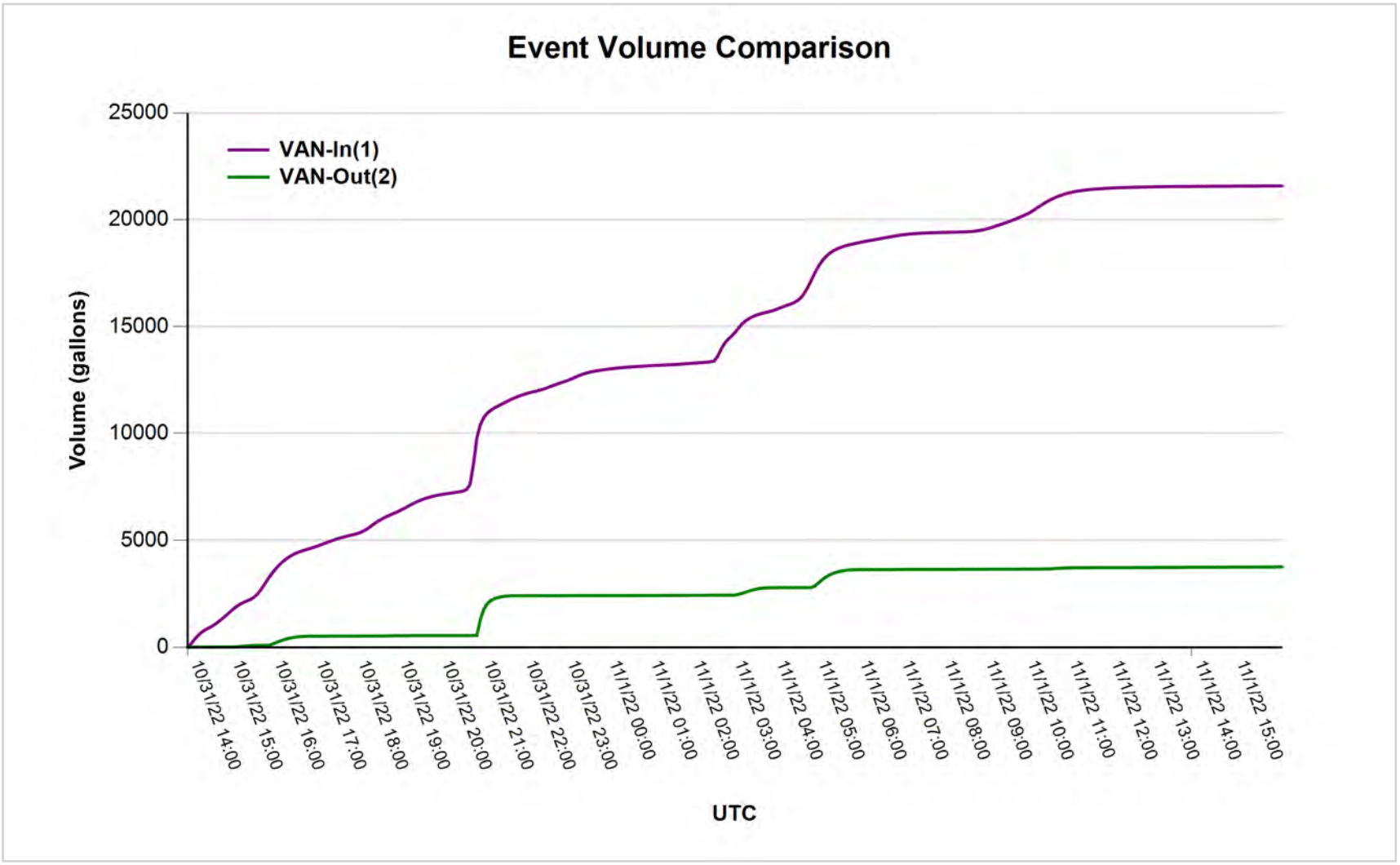
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.29	03/04/2023 08:35	03/04/2023 19:30	10.92	32.83

Aliquots								Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	7	03/04/2023 11:15	03/04/2023 19:25	8.17	250	1,750	4.00	5.10
2	VAN-Out	5	03/04/2023 14:55	03/04/2023 16:15	1.33	250	1,250	4.00	4.40

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	03/04/2023 08:40	03/04/2023 22:50	14.17	4,770.2	336.6	4,770.2	4,639.0	97.20	31.30	0.01	5.89	0.221	
2	VAN-Out	03/04/2023 10:50	03/04/2023 19:55	9.08	1,235.8	136.1	1,235.8	1,064.6	86.10	16.25	0.13	3.69	0.124	

No comments added for this event

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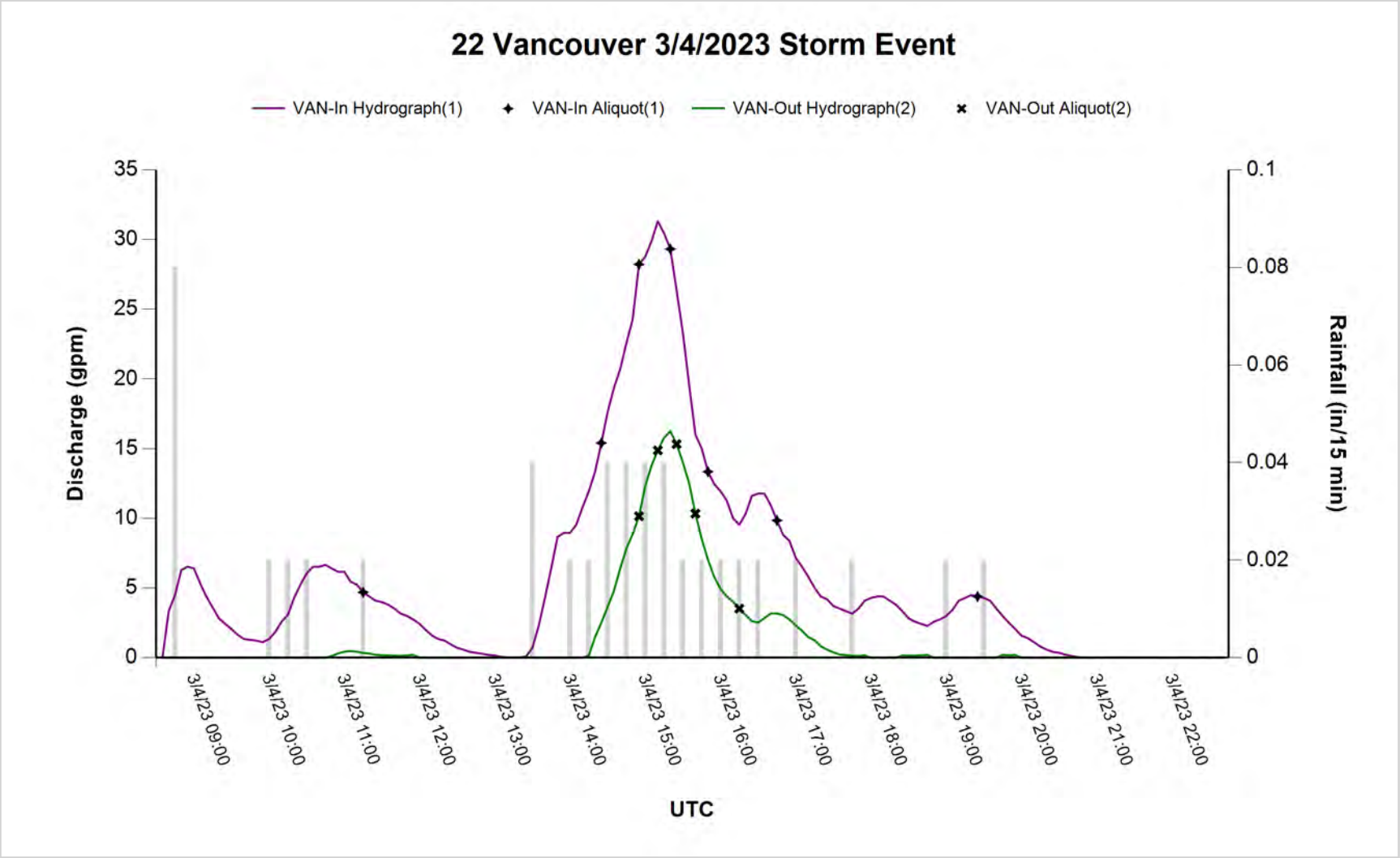
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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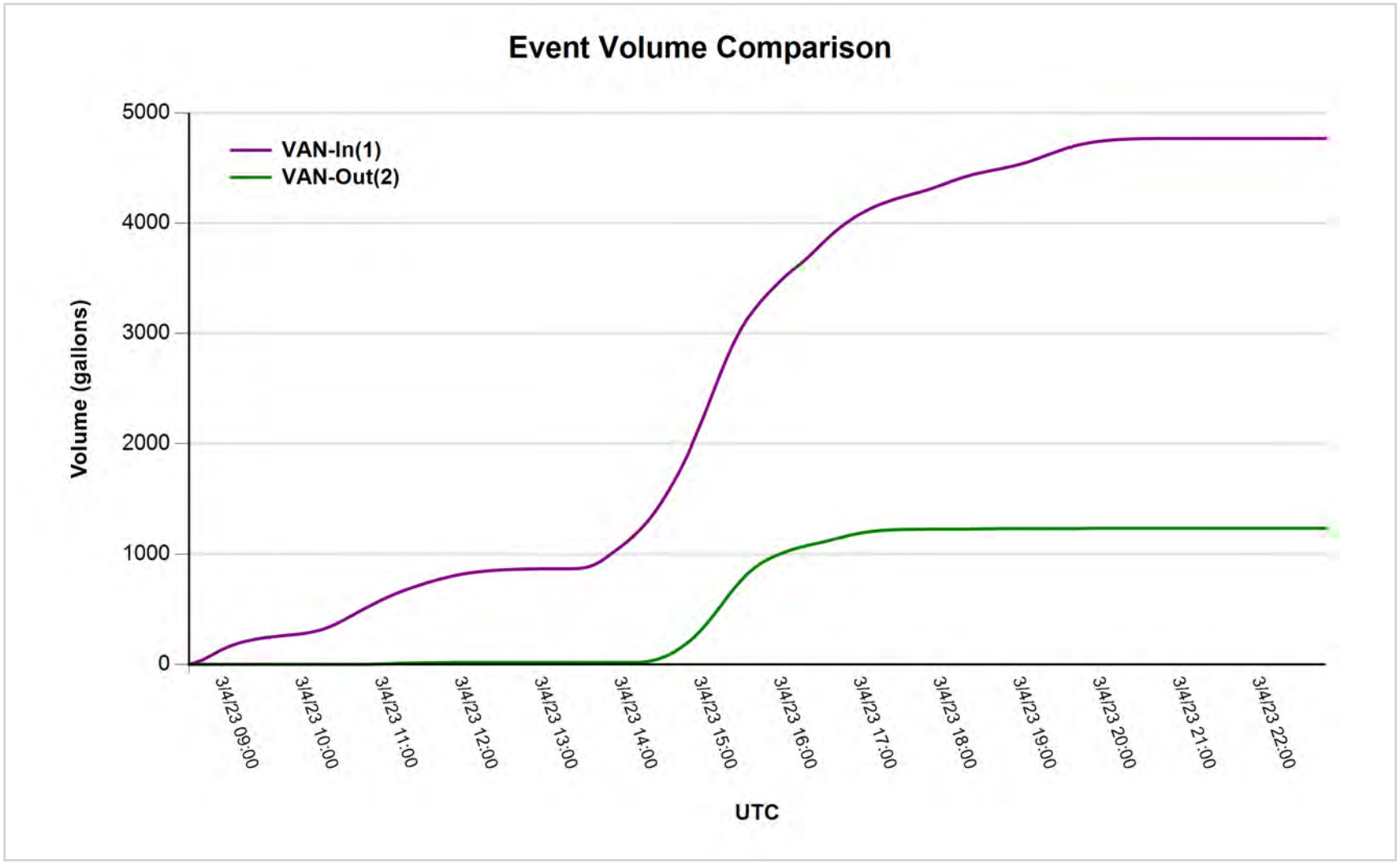
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.32	04/01/2023 01:55	04/01/2023 09:15	7.33	81.08

Aliquots								Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	13	04/01/2023 02:20	04/01/2023 07:25	5.08	250	3,250	7.70	9.00
2	VAN-Out	17	04/01/2023 02:45	04/01/2023 08:05	5.33	250	4,250	7.60	8.70

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	04/01/2023 02:00	04/01/2023 12:15	10.25	7,697.2	750.9	7,697.2	7,560.8	98.20	60.74	0.01	12.94	0.304	
2	VAN-Out	04/01/2023 02:30	04/01/2023 08:25	5.92	4,497.7	759.7	4,497.7	4,493.3	99.90	42.45	0.13	12.67	0.211	

No comments added for this event

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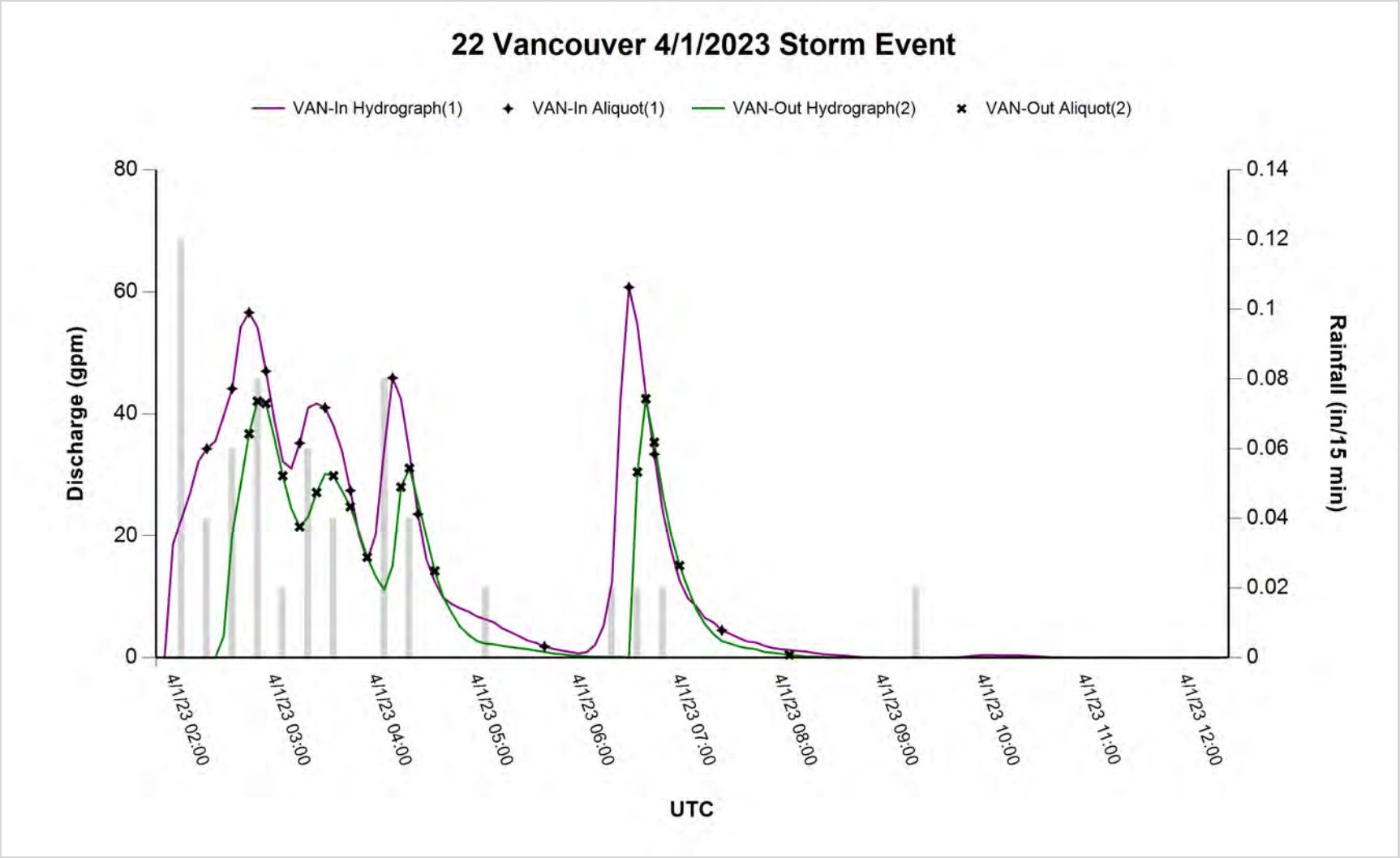
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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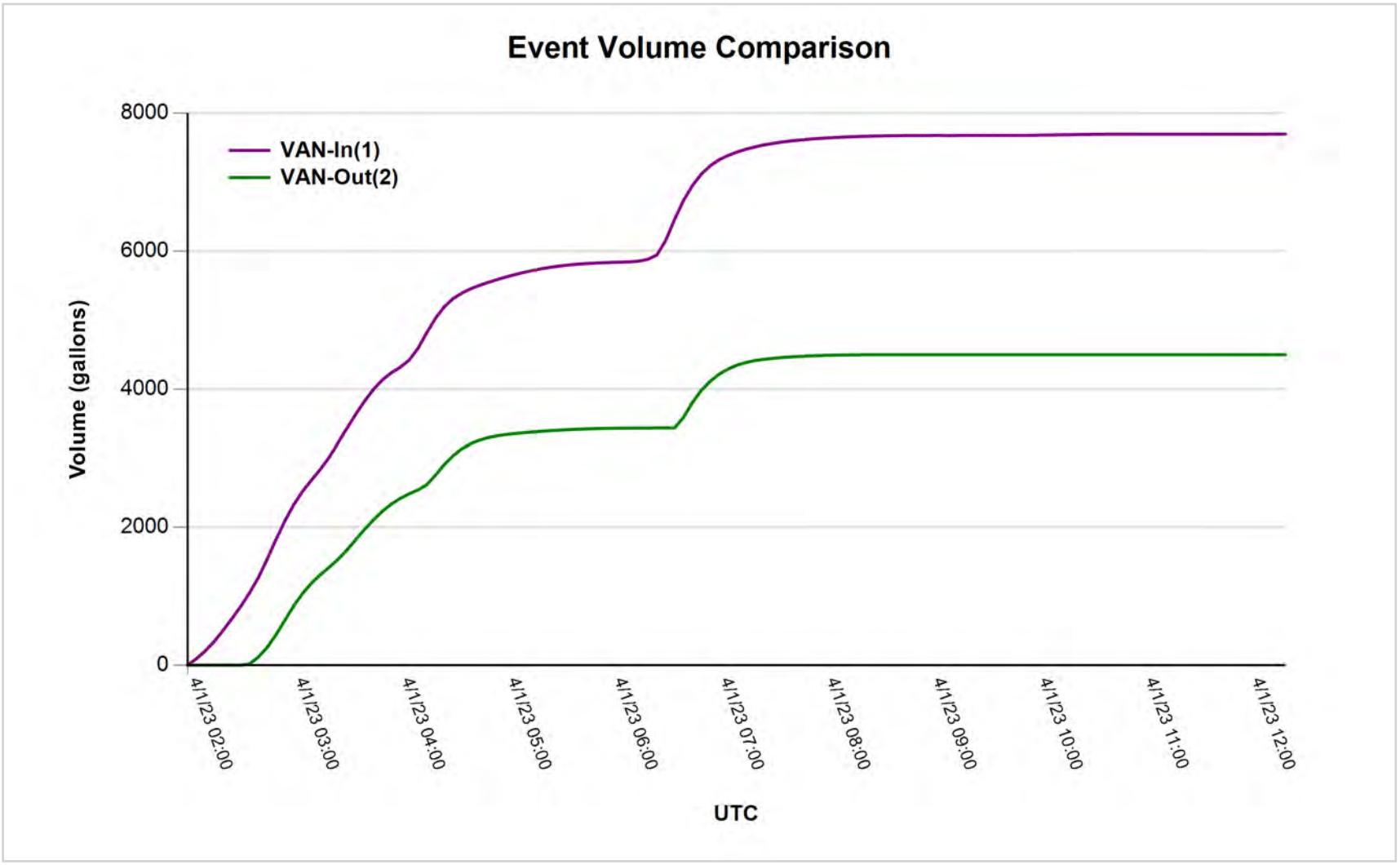
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.61	10/24/2023 19:05	10/25/2023 07:00	11.92	187.33

Aliquots								Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	15	10/24/2023 20:05	10/25/2023 06:50	10.75	250	3,750	10.30	13.30
2	VAN-Out	15	10/25/2023 01:00	10/25/2023 06:20	5.33	250	3,750	10.30	12.00

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	10/24/2023 19:30	10/25/2023 11:00	15.50	8,049.0	519.3	8,049.0	7,927.5	98.50	55.78	0.01	10.39	0.292	
2	VAN-Out	10/24/2023 23:35	10/25/2023 07:10	7.58	3,310.9	436.8	3,310.9	3,202.4	96.70	46.64	0.13	9.88	0.222	

No comments added for this event

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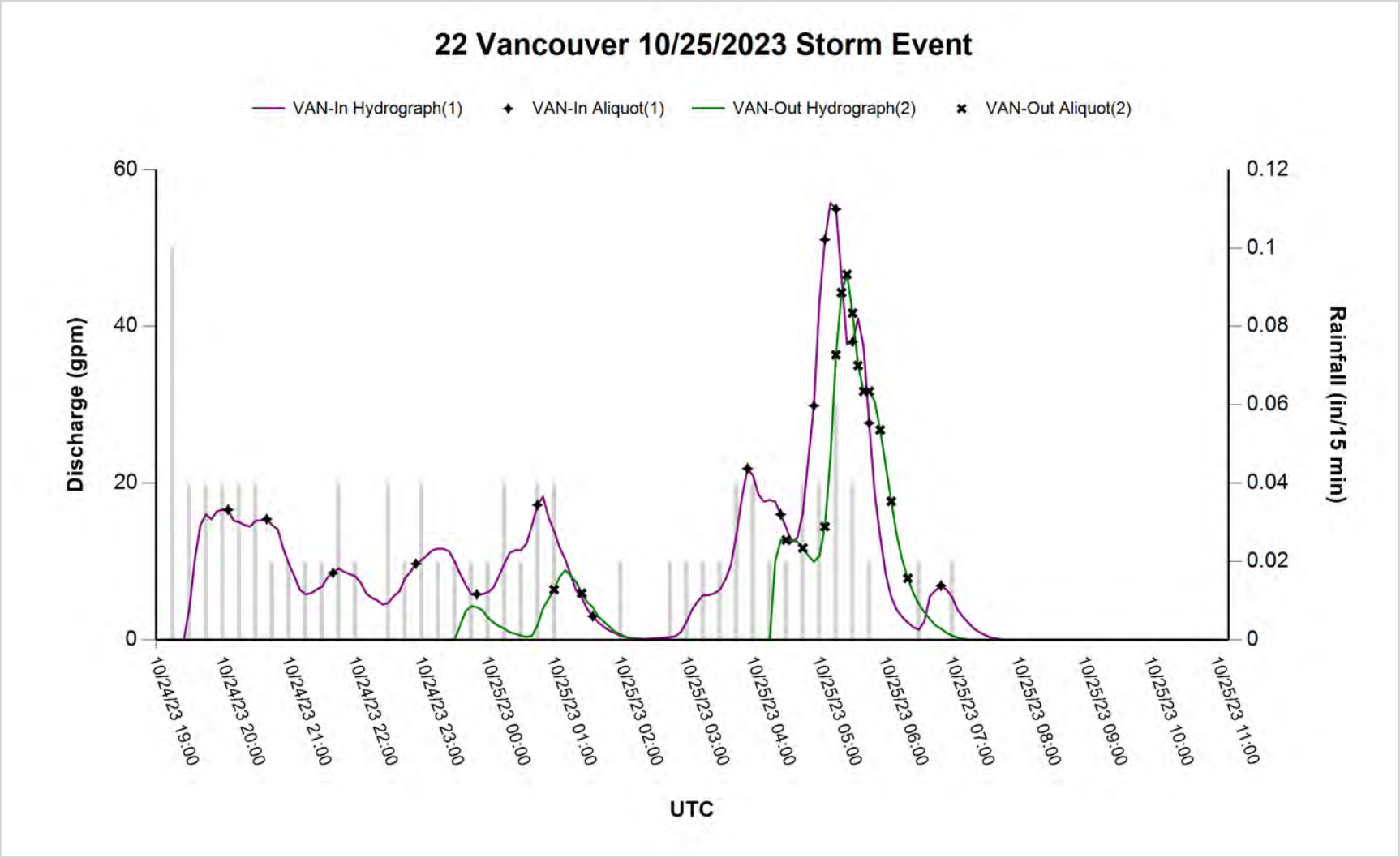
Drainage Area (acres):



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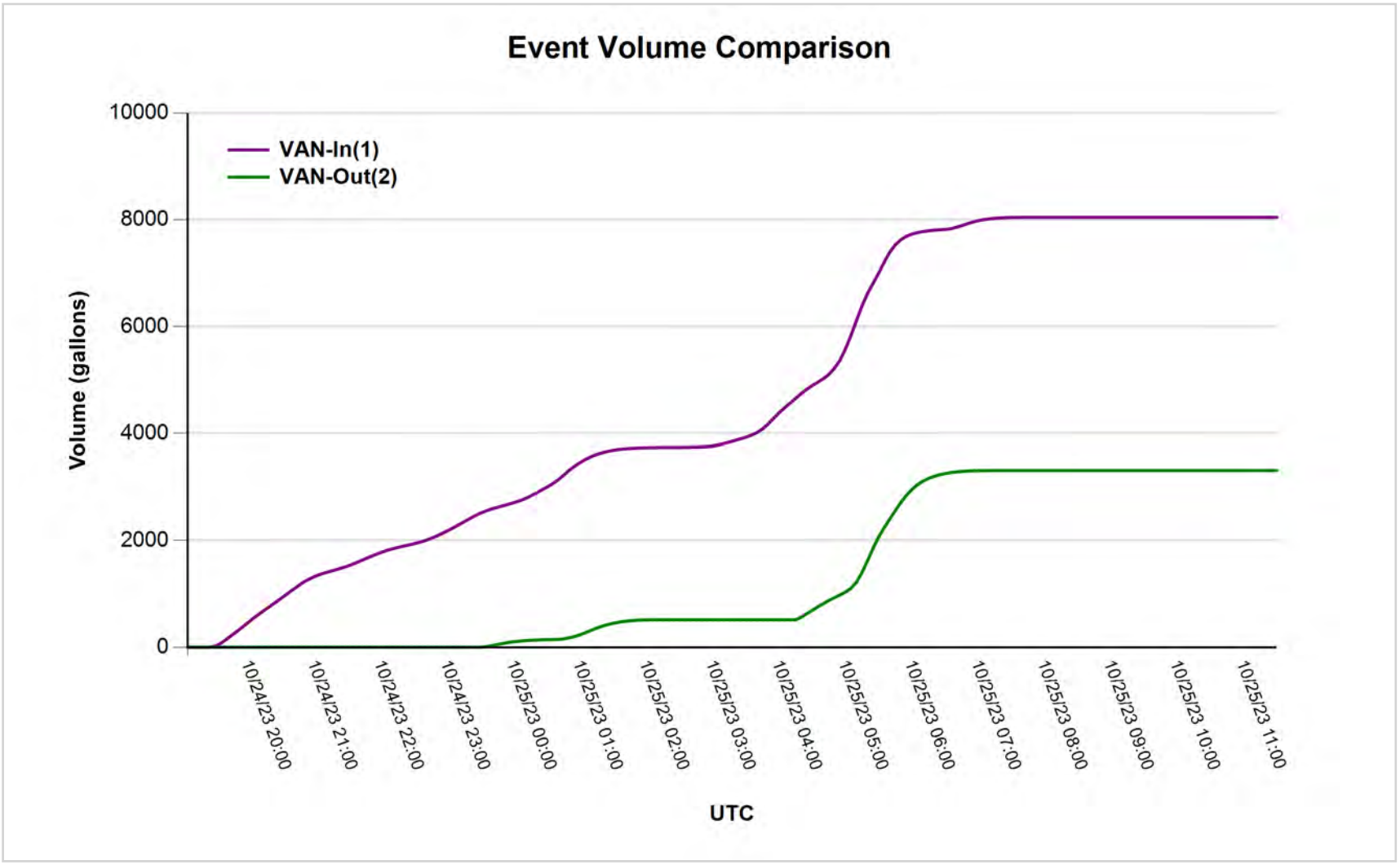
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.89	11/01/2023 20:45	11/02/2023 16:55	20.17	3483.50

Aliquots							Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	14	11/01/2023 22:55	11/02/2023 17:30	18.58	250	3,500	10.20	12.90
2	VAN-Out	6	11/02/2023 00:35	11/02/2023 05:50	5.25	250	1,500	10.20	11.40

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	11/01/2023 20:50	11/02/2023 18:05	21.25	16,726.9	787.1	16,726.9	16,651.7	99.60	70.00	0.22	13.07	0.325	
2	VAN-Out	11/01/2023 23:25	11/02/2023 12:25	13.00	4,934.0	379.5	4,934.0	4,775.9	96.80	35.34	0.13	10.17	0.191	

No comments added for this event

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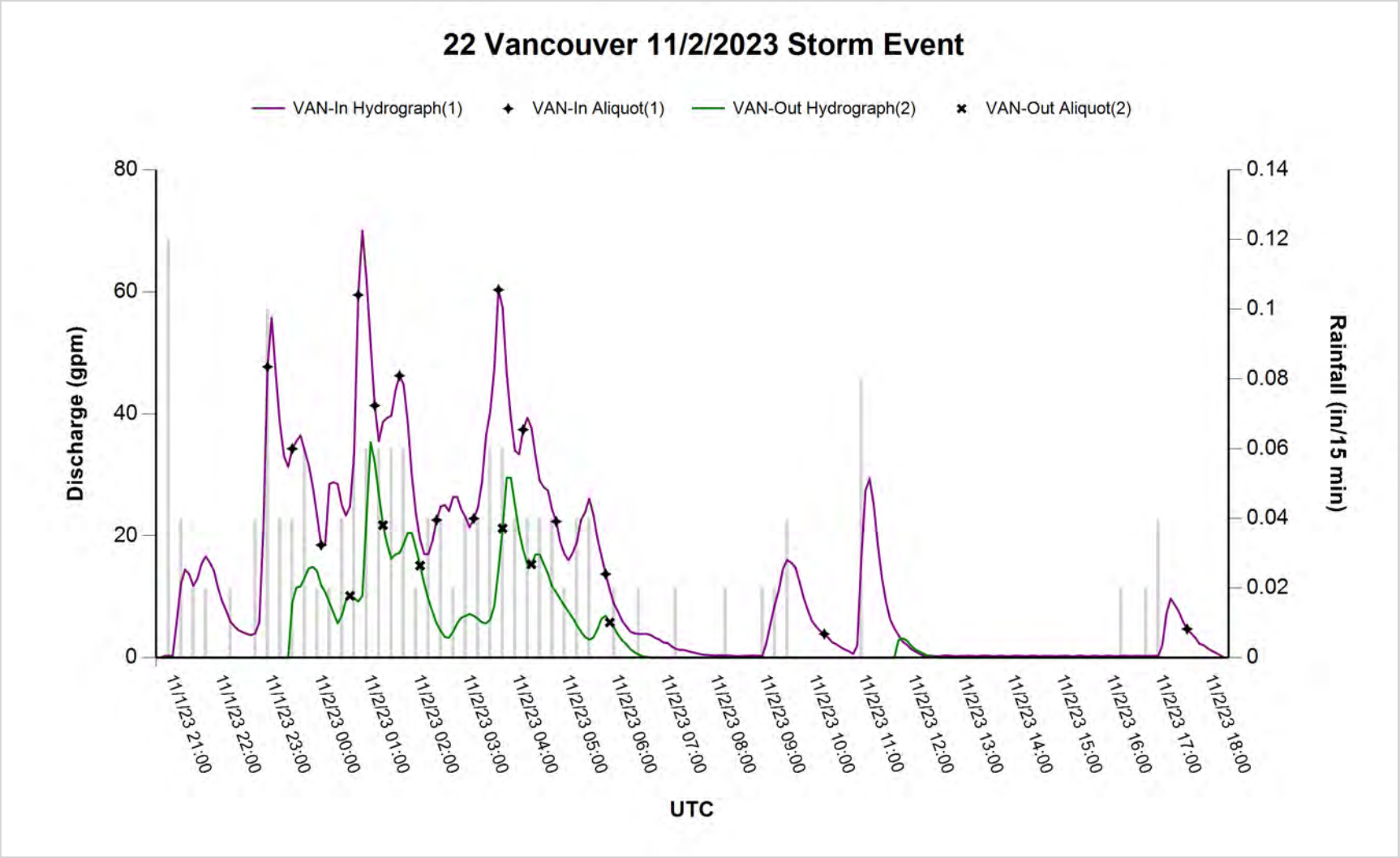
Drainage Area (acres):



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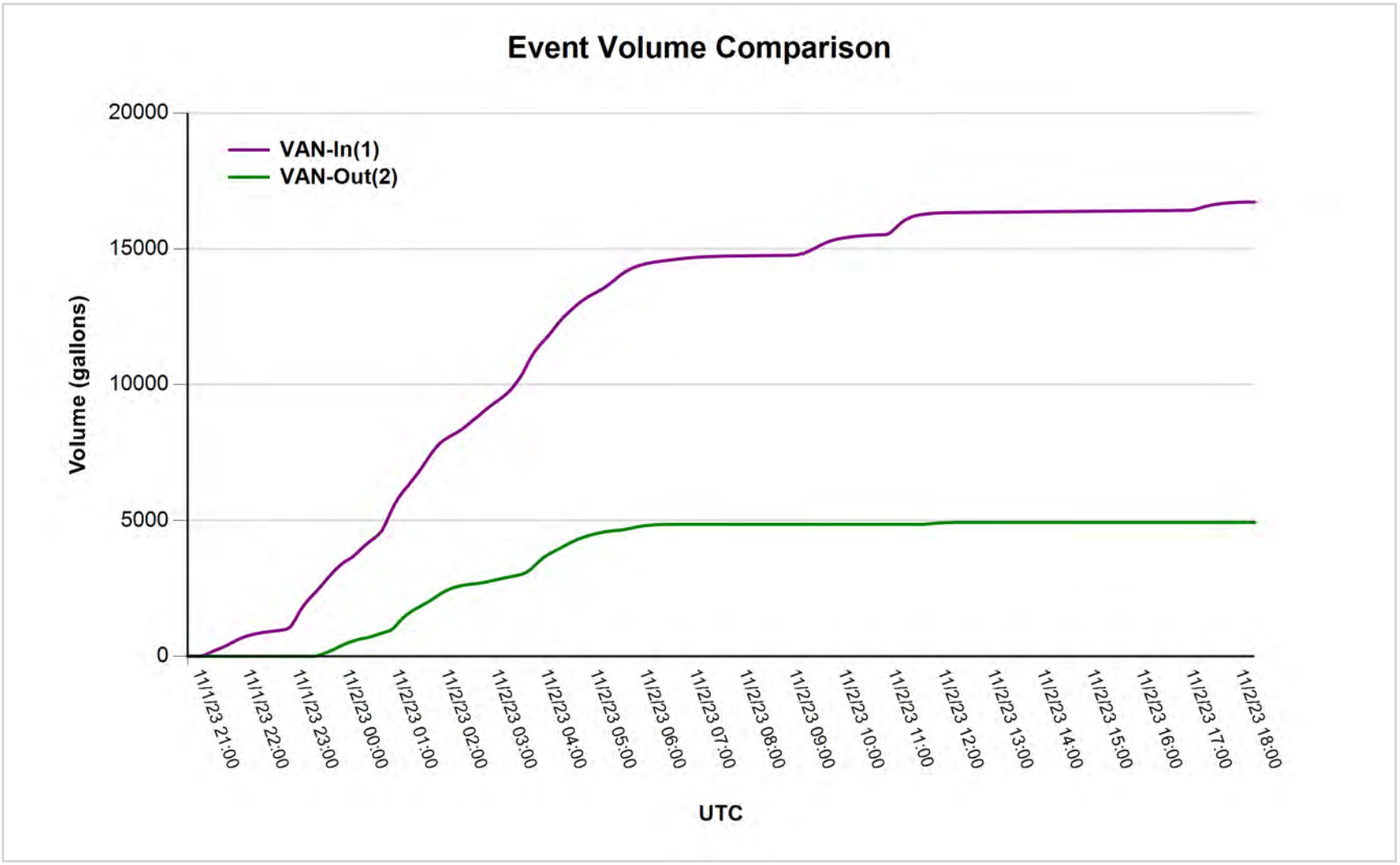
Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.33	11/19/2023 02:00	11/19/2023 09:05	7.08	28.08

Aliquots								Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	11	11/19/2023 02:35	11/19/2023 06:10	3.58	250	2,750	8.80	10.10
2	VAN-Out	10	11/19/2023 03:45	11/19/2023 06:10	2.42	250	2,500	8.80	9.50

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	11/19/2023 02:05	11/19/2023 11:50	9.75	6,100.3	625.7	6,100.3	5,833.2	95.60	47.32	0.23	10.34	0.270	
2	VAN-Out	11/19/2023 03:15	11/19/2023 07:05	3.83	2,286.9	597.1	2,286.9	2,141.8	93.70	29.82	0.16	9.73	0.174	

No comments added for this event

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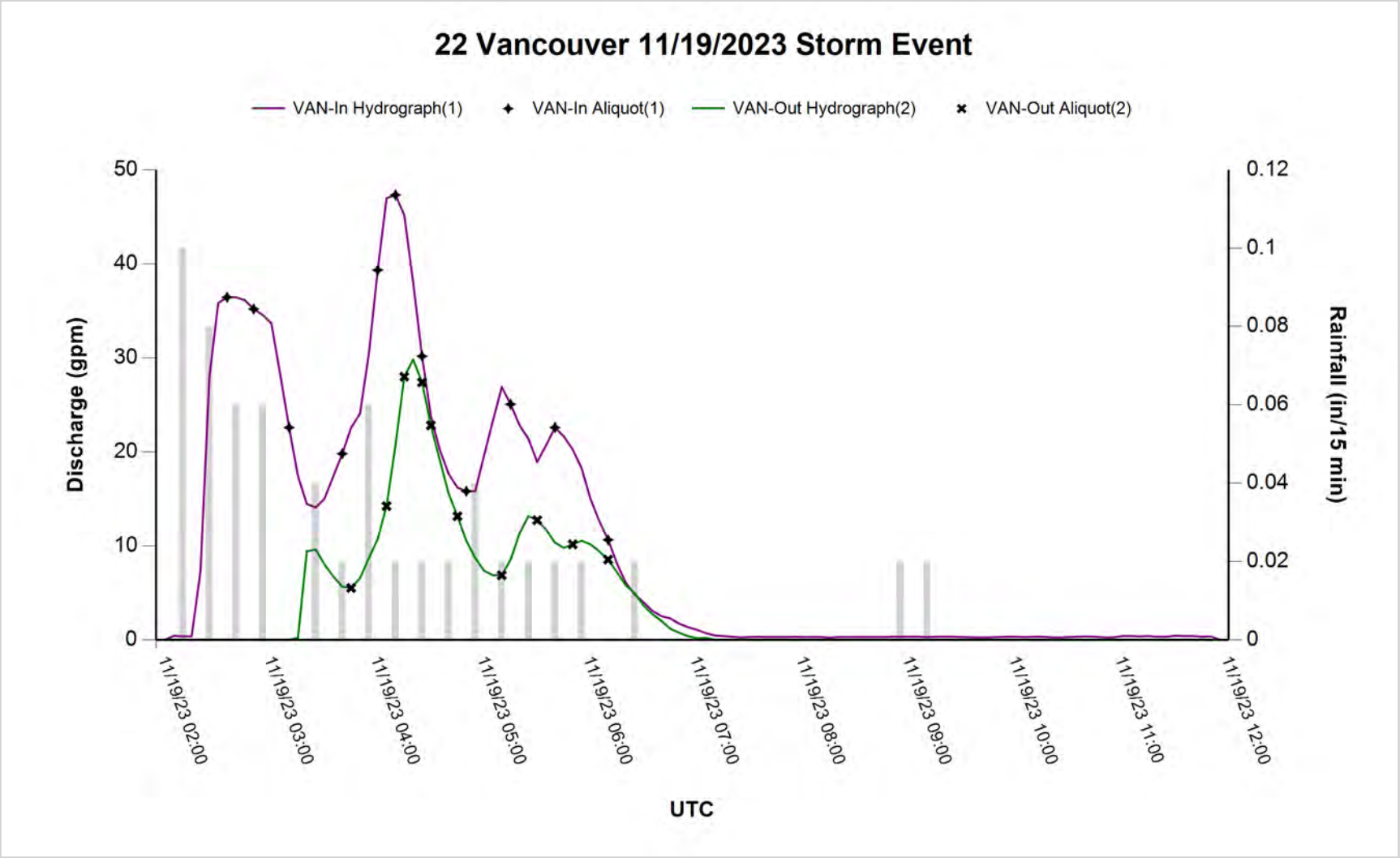
Drainage Area (acres):



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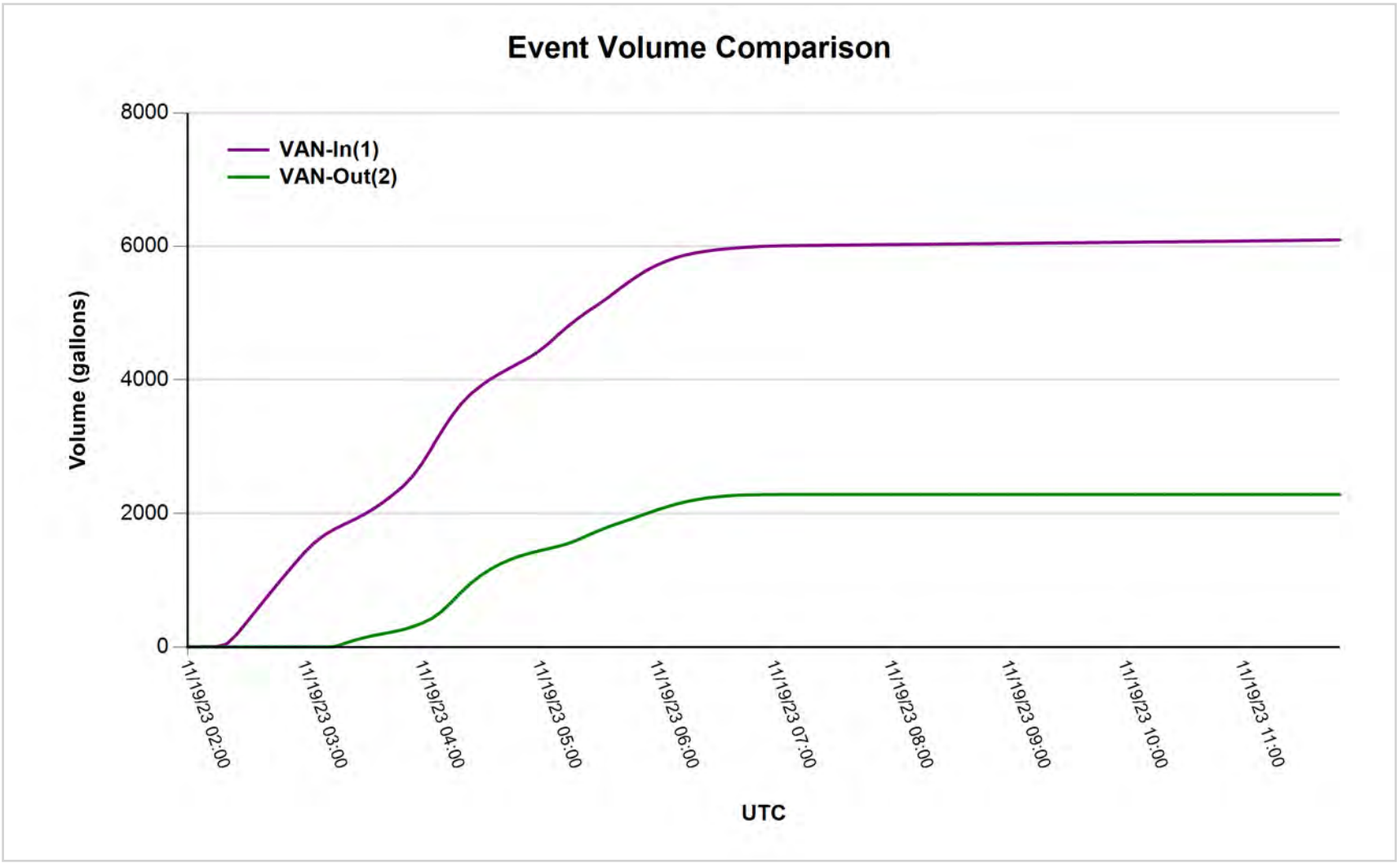
Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.77	12/03/2023 04:25	12/03/2023 22:35	18.17	12.24

Aliquots							Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	20	12/03/2023 05:40	12/03/2023 23:05	17.42	250	5,000	7.70	10.50
2	VAN-Out	37	12/03/2023 05:45	12/03/2023 17:00	11.25	250	9,250	7.70	8.40

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	12/03/2023 04:30	12/03/2023 23:10	18.67	14,834.4	794.6	14,834.4	14,814.5	99.90	76.13	0.01	20.75	0.338	
2	VAN-Out	12/03/2023 04:30	12/03/2023 19:40	15.17	14,238.5	938.6	14,238.5	11,816.1	83.00	82.88	0.13	15.65	0.301	

No comments added for this event

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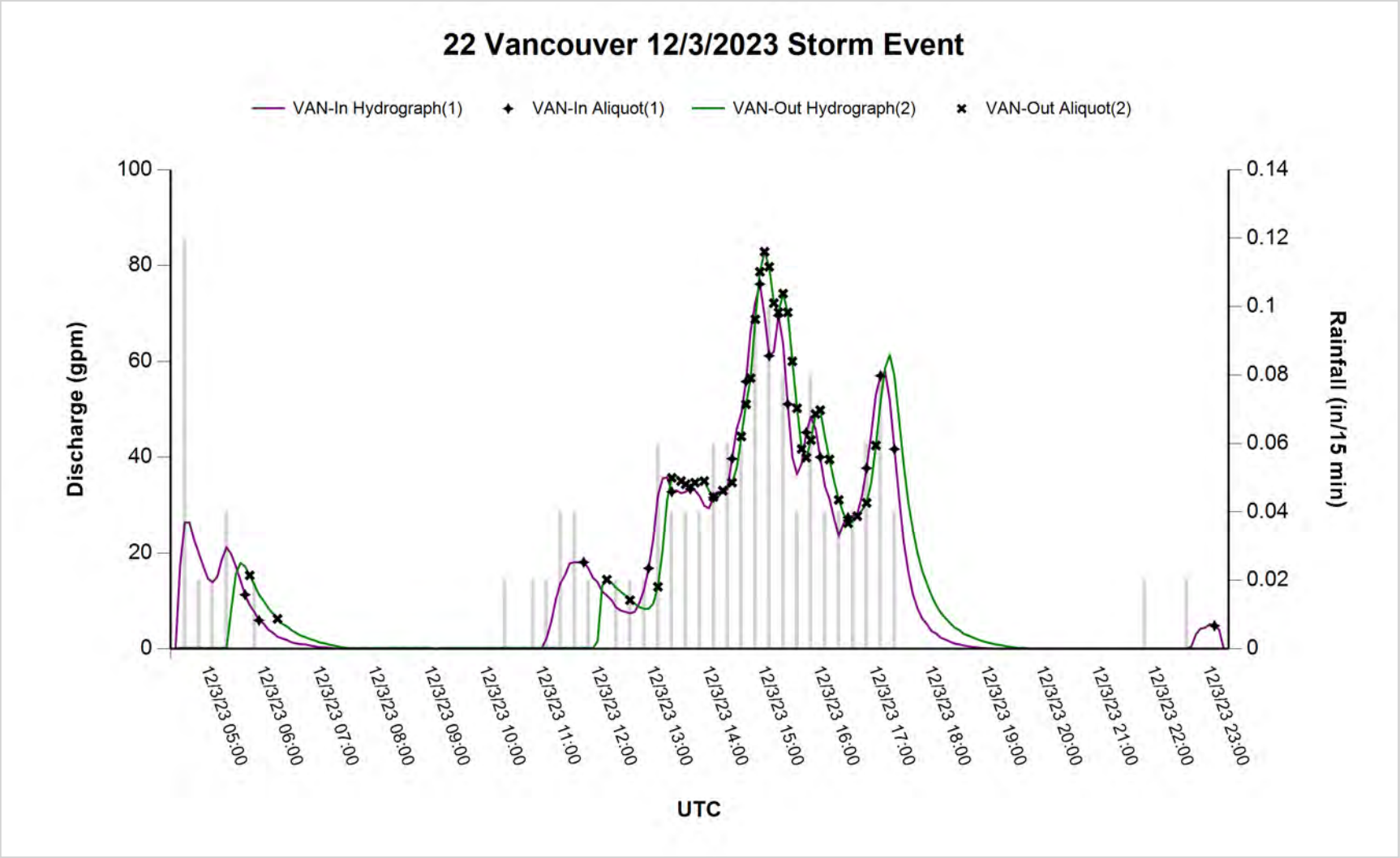
Drainage Area (acres):



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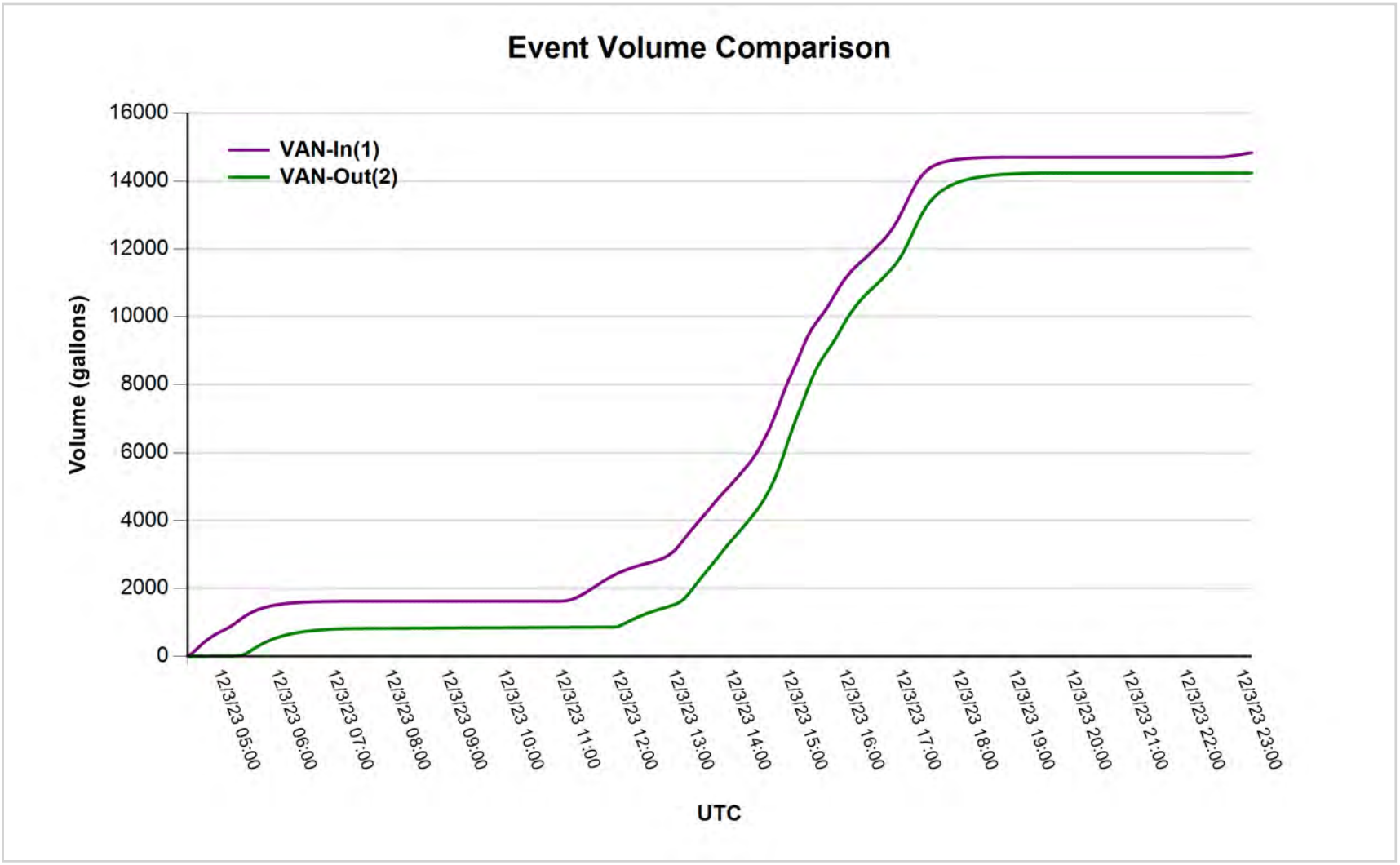
Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.73	04/25/2024 12:45	04/26/2024 06:20	17.58	7469.16

Aliquots							Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	37	04/25/2024 14:15	04/26/2024 00:50	10.58	250	9,250	13.30	14.70
2	VAN-Out	23	04/25/2024 16:25	04/26/2024 01:40	9.25	250	5,750	13.50	14.70

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	04/25/2024 12:50	04/26/2024 06:50	18.00	22,841.6	1269.0	22,841.6	19,618.2	85.90	103.69	4.91	21.05	0.390	
2	VAN-Out	04/25/2024 12:50	04/26/2024 06:50	18.00	7,576.0	420.9	7,576.0	7,320.4	96.60	63.15	0.13	6.98	0.261	

No comments added for this event

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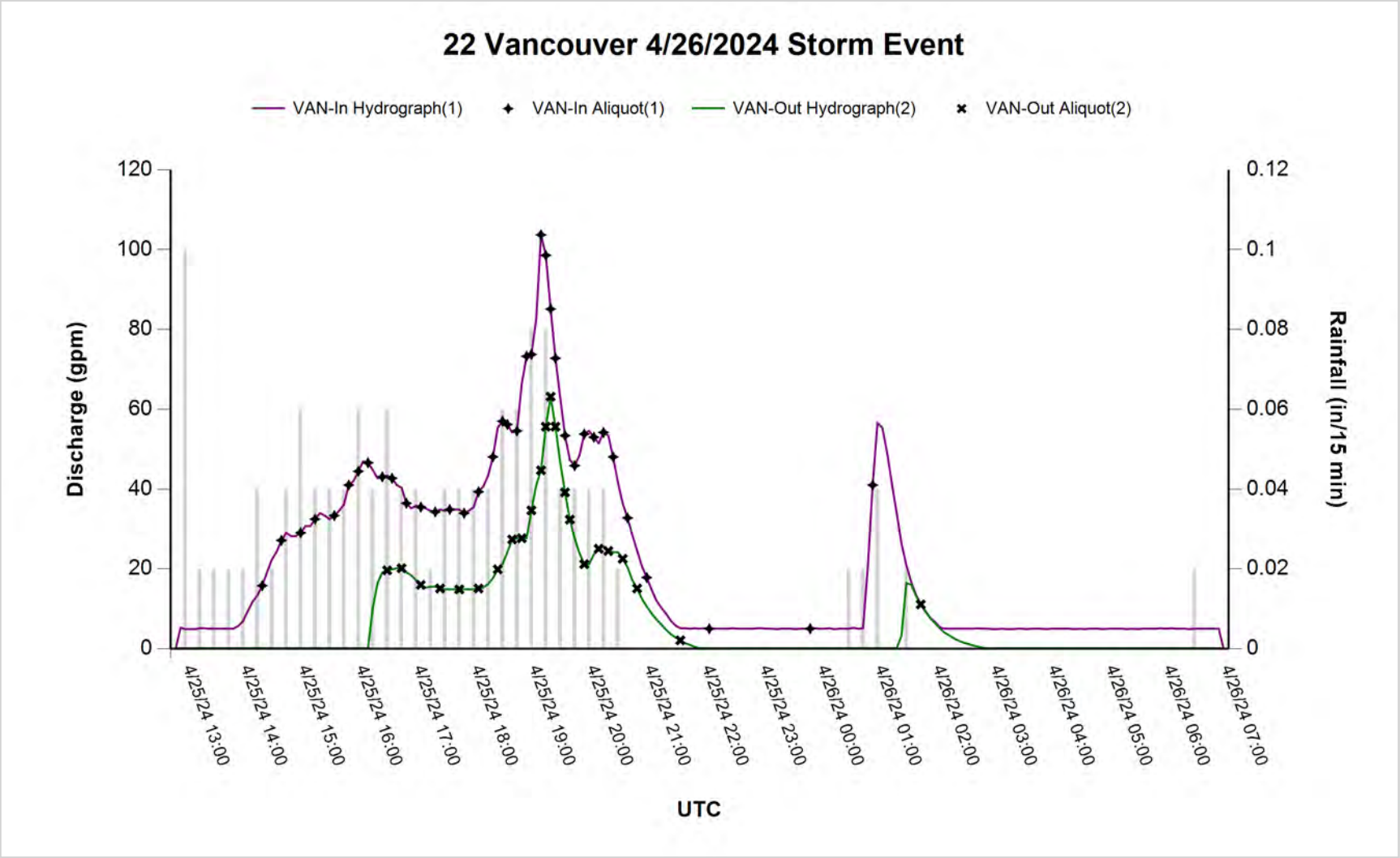
Drainage Area (acres):



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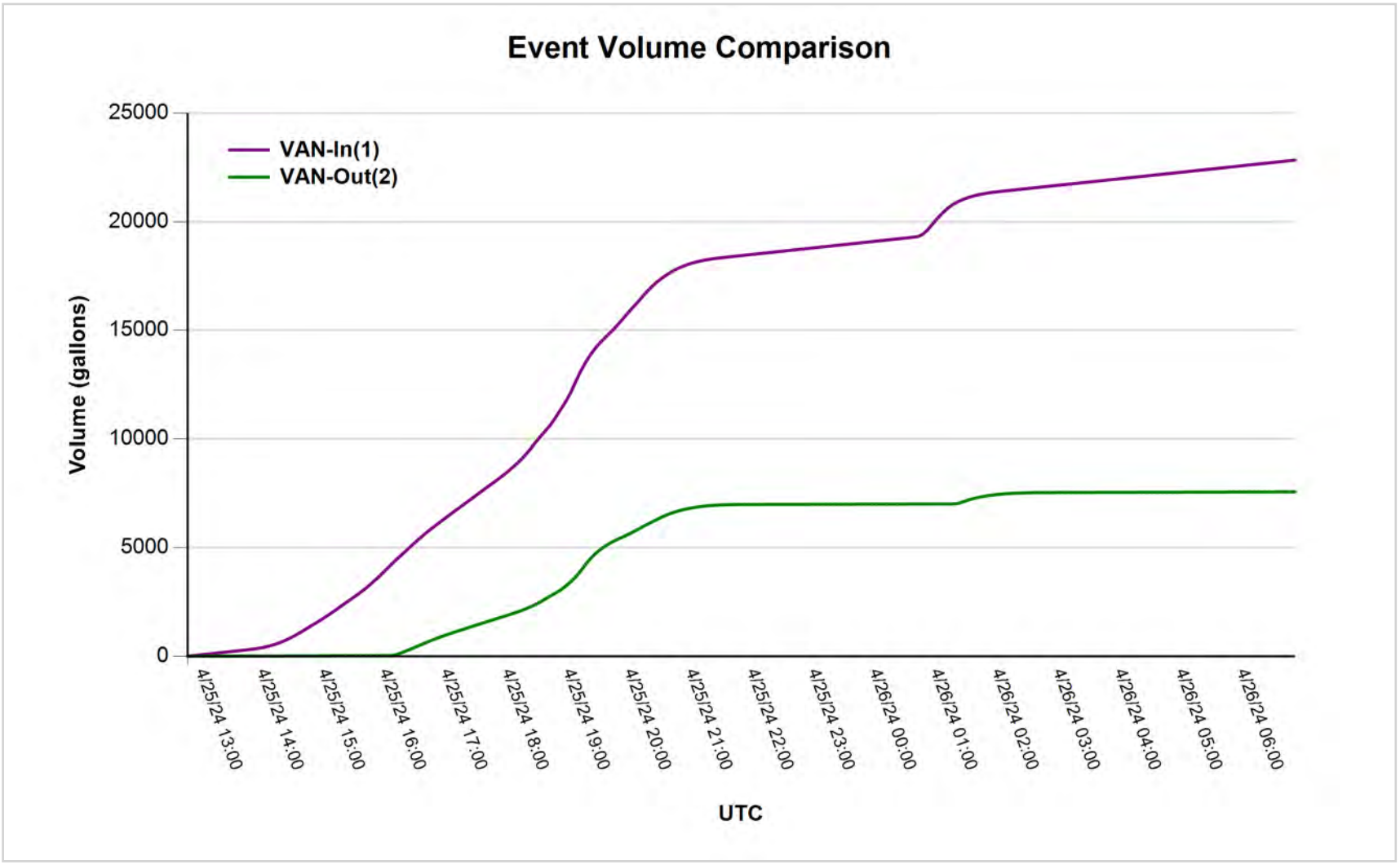
Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
0.66	05/21/2024 19:45	05/22/2024 06:55	11.17	613.08

Aliquots								Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	12	05/21/2024 21:00	05/22/2024 02:25	5.42	250	3,000	14.60	17.10
2	VAN-Out	8	05/21/2024 23:00	05/22/2024 02:55	3.92	250	2,000	14.50	16.10

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	05/21/2024 20:30	05/22/2024 03:35	7.08	6,678.0	943.2	6,678.0	6,396.7	95.80	35.50	0.01	15.53	0.235	
2	VAN-Out	05/21/2024 22:30	05/22/2024 03:30	5.00	2,581.8	516.4	2,581.8	2,537.5	98.30	20.42	0.15	8.47	0.141	

No comments added for this event

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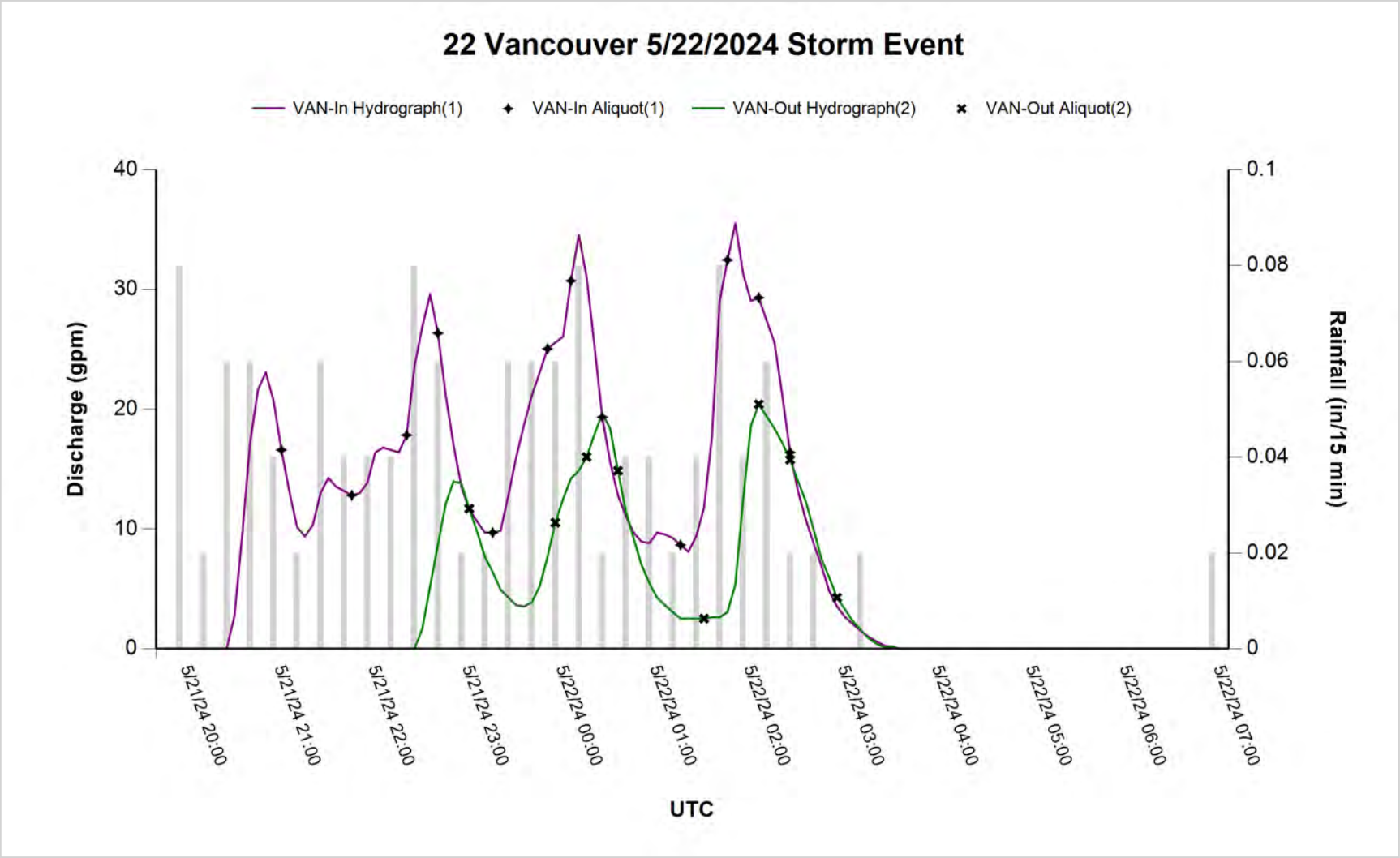
Drainage Area (acres):



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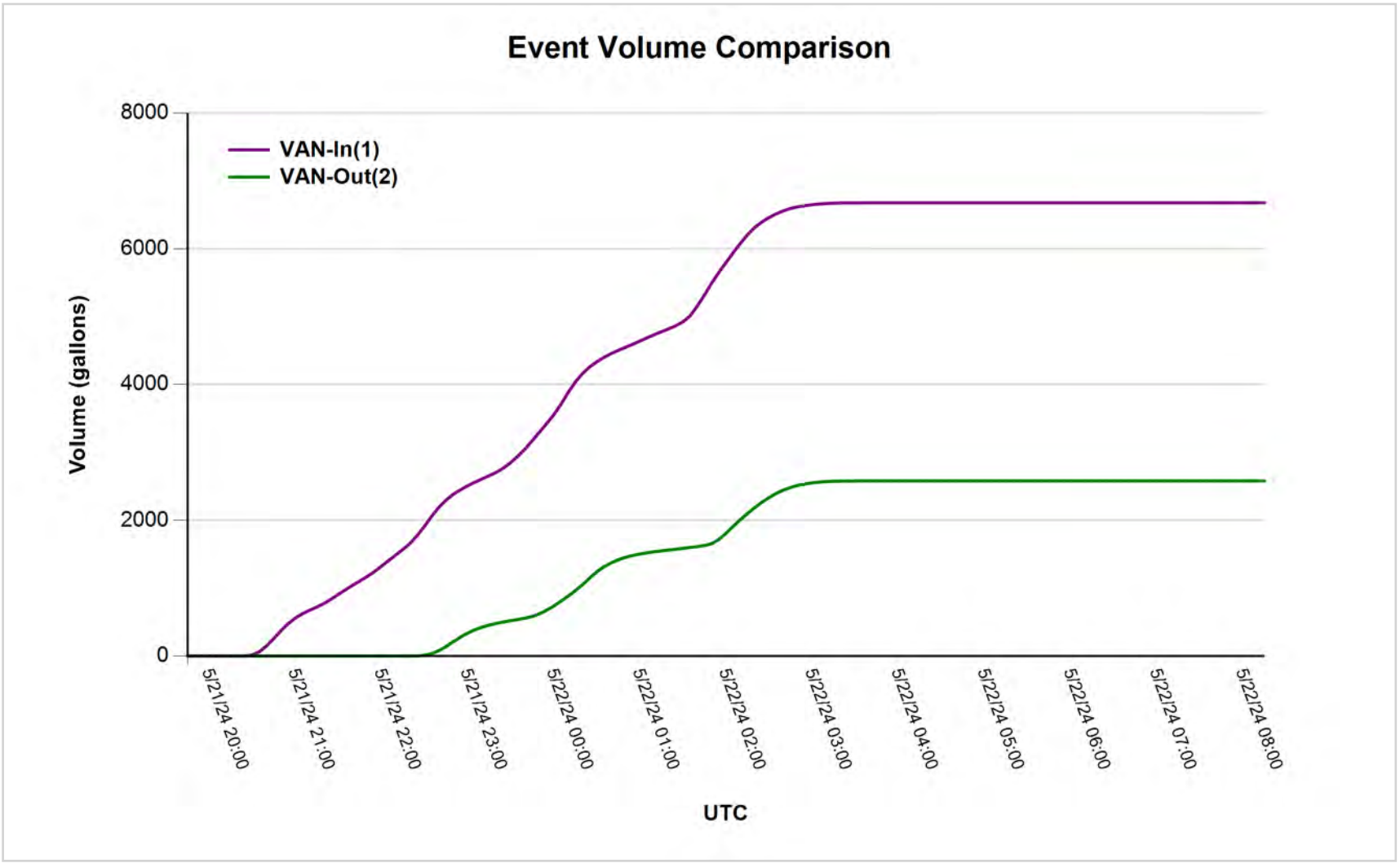
Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):

Precipitation				
Total (in)	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Antecedent Dry (hrs)
1.08	06/02/2024 18:15	06/03/2024 09:50	15.58	3489.08

Aliquots								Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (UTC)	Last Aliquot Time (UTC)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	31	06/02/2024 18:50	06/03/2024 09:20	14.50	250	7,750	15.40	18.00
2	VAN-Out	33	06/02/2024 19:30	06/03/2024 09:35	14.08	250	8,250	15.40	17.50

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (UTC)	End Time (UTC)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	06/02/2024 18:25	06/03/2024 14:50	20.42	23,541.7	1152.9	23,541.7	22,986.6	97.60	74.69	0.01	23.42	0.335	
2	VAN-Out	06/02/2024 19:15	06/03/2024 10:25	15.17	13,377.5	881.8	13,377.5	13,142.8	98.20	51.03	0.13	18.08	0.233	

No comments added for this event

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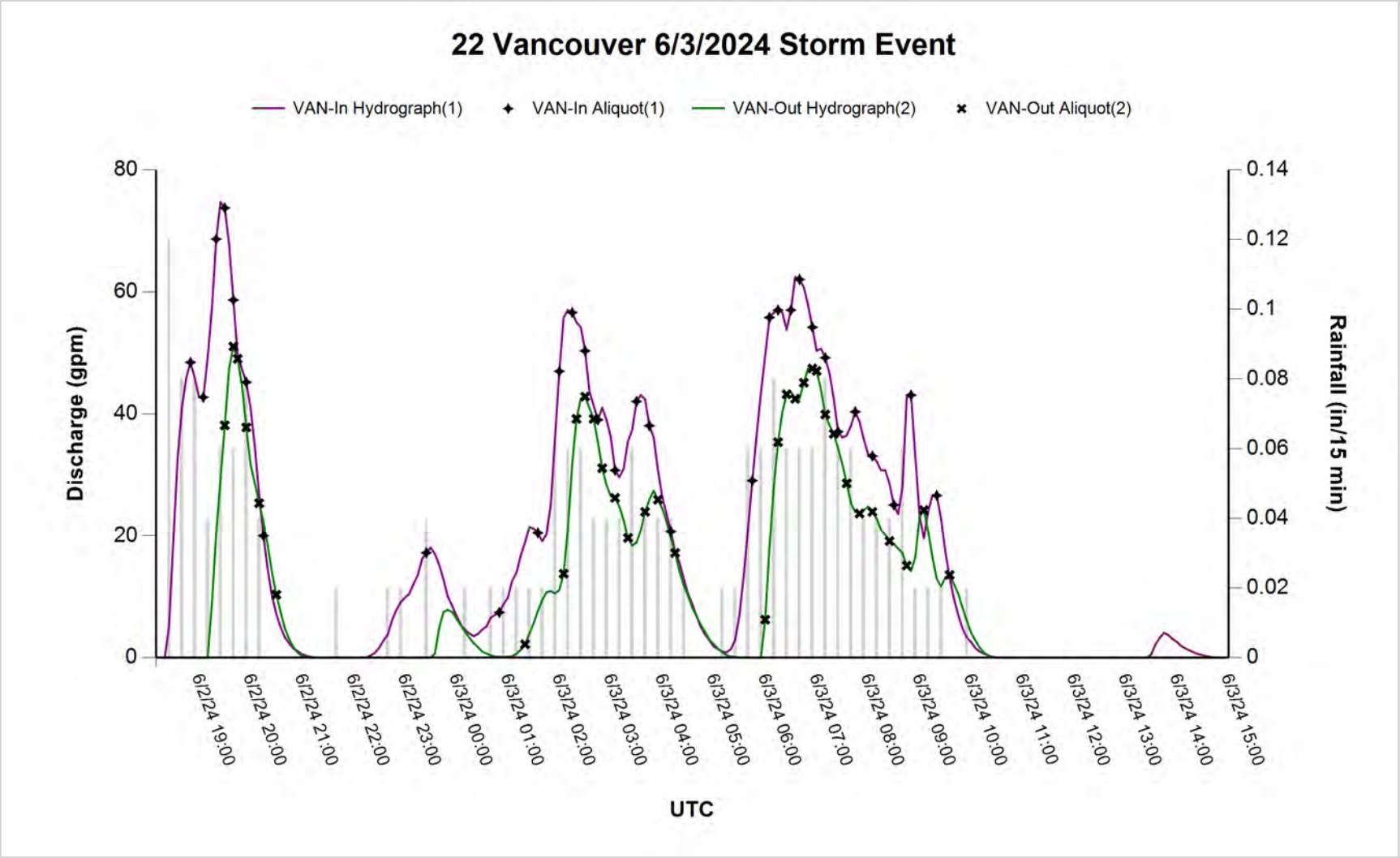
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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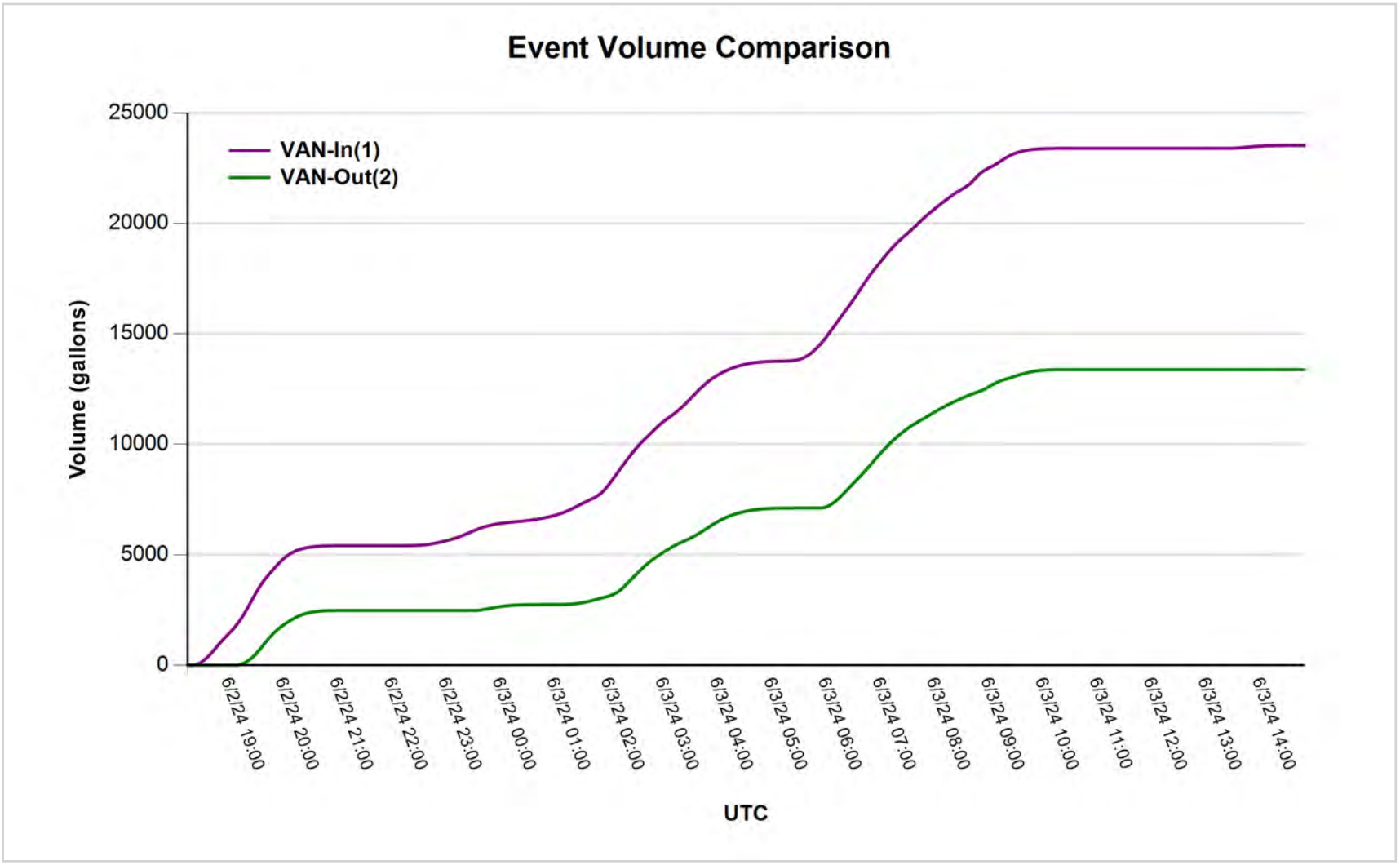
Lat: 45.682453N **Long:** -122.551595W

Drainage Area (acres):



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Lat: 45.682453N **Long:** -122.551595W

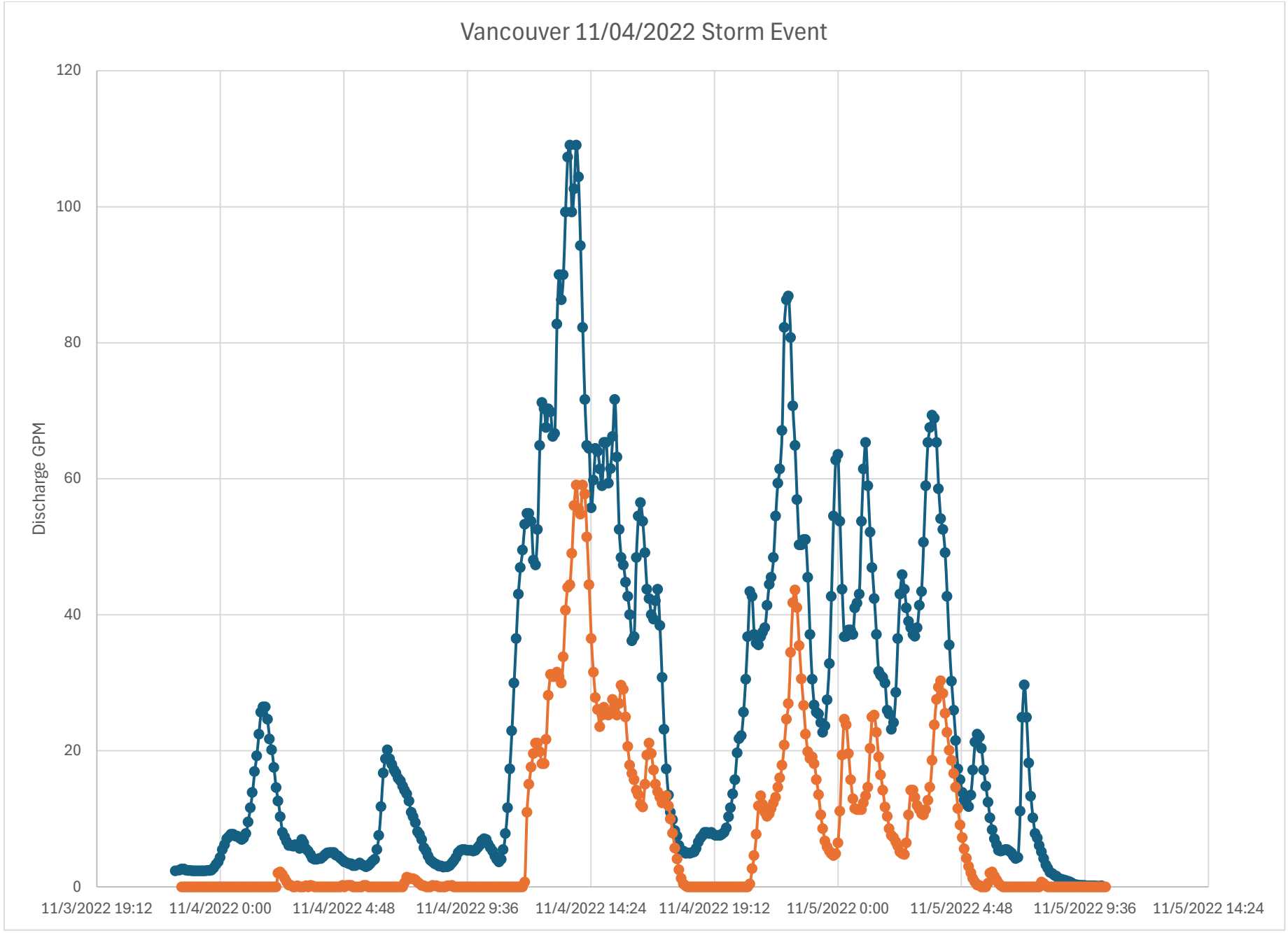
Drainage Area (acres):

Precipitation				
Total (in)	Start Time (Pacific)	End Time (Pacific)	Duration (hrs)	Antecedent Dry (hrs)
1.07	11/03/2022 22:00	11/05/2022 11:15	32.92	27.93

Aliquots							Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (Pacific)	Last Aliquot Time (Pacific)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	27	11/04/2022 01:50	11/04/2022 22:25	20.58	250	6,750	8.6	13.10
2	VAN-Out	32	11/04/2022 12:10	11/04/2022 17:20	10.42	250	8,000	8.8	12.8

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (Pacific)	End Time (Pacific)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	11/03/2022 22:30	11/04/2022 12:15	14.67	36,303.6	1712.4	36,303.6	34324.8	94.55	110.77	0.1	25.5	0.40	
2	VAN-Out	11/04/2022 2:15	11/04/2022 12:45	10.42	11886.0	597.47	11886.0	11885.97	100	60.0	0.13	9.06	0.30	

No comments added for this event


Vancouver 11/04/2022 Storm Event
Discharge GPM
120
100
80
60
40
20
0
11/3/2022 19:12
11/4/2022 0:00
11/4/2022 4:48
11/4/2022 9:36
11/4/2022 14:24
11/4/2022 19:12
11/5/2022 0:00
11/5/2022 4:48
11/5/2022 9:36
11/5/2022 14:24

Download 22 Vancouver

Lat: 45.682453N **Long:** -122.551595W

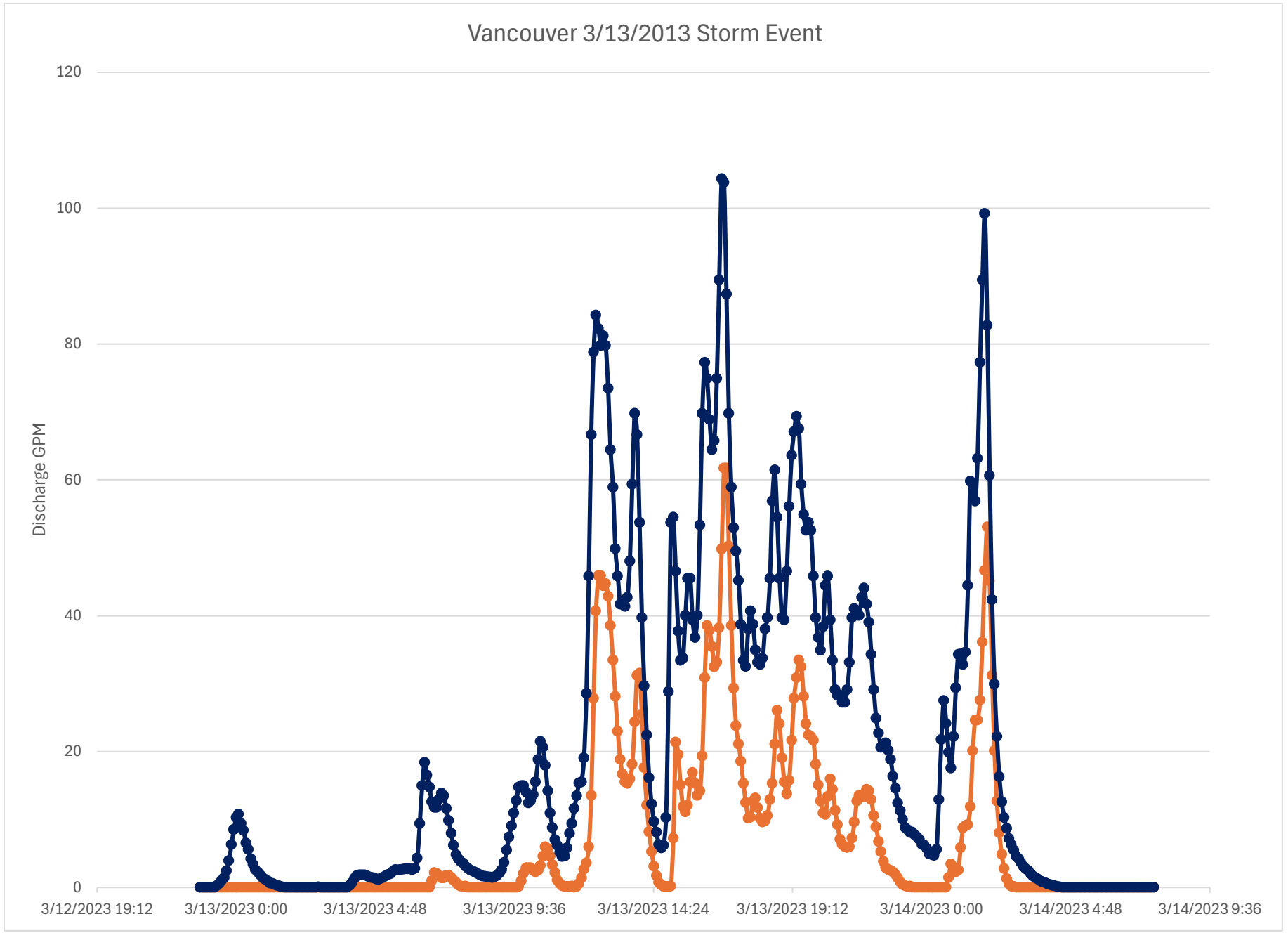
Drainage Area (acres):

Precipitation				
Total (in)	Start Time (Pacific)	End Time (Pacific)	Duration (hrs)	Antecedent Dry (hrs)
1.45	03/12/2023 22:40	03/14/2023 01:55	26.58	6.17

Aliquots							Water Temp	
Sample Point (m)	Sample Point Name	Aliquots Collected	First Aliquot Time (Pacific)	Last Aliquot Time (Pacific)	Sampling Duration (hrs)	Volume (mL)	Total Sample Volume (mL)	Min (°C)	Max (°C)
1	VAN-In	37	03/13/2023 06:30	3/13/2023 24:30	17.17	250	9,250	2.90	9.0
2	VAN-Out	36	03/13/2023 12:10	03/14/2023 02:05	12.83	250	9,000	5.30	7.50

Runoff / Discharge														
		Runoff Time			Volume			Sampled		Flow			Stage	
Sample Point (m)	Sample Point Name	Start Time (Pacific)	End Time (Pacific)	Duration (hrs)	Total (gal)	Intensity (gal/hr)	First 24Hrs (gal)	Discharge Total Volume Sampled (gal)	% Hydrograph Sampled	Peak (gpm)	Min (gpm)	Mean (gpm)	Max (ft)	Hydrology Validation Code
1	VAN-In	03/12/2022 22:40	03/14/2022 05:10	29.33	40,477.9	1,334.77	40,477.9	34,232.65	84.57	106.02	0.1	15.15	0..4	
2	VAN-Out	03/13/2023 06:45	03/14/2022 02:10	19.92	14,566	482.19	14,566	14,308.99	98.23	62.7	0.13	27.85	0..3	

No comments added for this event


Vancouver 3/13/2013 Storm Event
Discharge GPM
120
100
80
60
40
20
0
3/12/2023 19:12
3/13/2023 0:00
3/13/2023 4:48
3/13/2023 9:36
3/13/2023 14:24
3/13/2023 19:12
3/14/2023 0:00
3/14/2023 4:48
3/14/2023 9:36