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Intake Efficiency Field Results for Federal Interagency Sedimentation Project Bag Samplers

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U.S. Department of the Interior
U.S. Geological Survey

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By Adam E. Manaster, Mark N. Landers, and Timothy D. Straub

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
	Length	
millimeter (mm)	0.03937	inch (in.)

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
	Flow rate	
foot per second (ft/s)	0.3048	meter per second (m/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as

$$°F = (1.8 \times °C) + 32.$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as

$$°C = (°F - 32) / 1.8.$$

Abbreviations

<	less than
>	greater than
ADCP	acoustic Doppler current profiler
ANOVA	analysis of variance
FISP	Federal Interagency Sedimentation Project
IE	intake efficiency
KW	Kruskal-Wallis
LOWESS	locally weighted scatterplot smoothing
SSC	suspended-sediment concentration
USGS	U.S. Geological Survey

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Abstract

The Federal Interagency Sedimentation Project (FISP) standardizes and advances sediment science among federal agencies. It is important to ensure that the FISP bag samplers perform isokinetically under all tested and approved conditions and collect samples that are representative of the stream or river cross-section. A measure of a sampler's isokinetic behavior is its intake efficiency, which is defined as the ratio of the velocity through the nozzle entrance of the sampler to the ambient stream velocity. The intake efficiencies of all FISP bag samplers and nozzle sizes were evaluated for this report. Samples were obtained across 31 U.S. Geological Survey streamflow-gaging stations between July 15, 2013, and June 17, 2020, where data were collected with all four bag samplers (US D-96, D-96-A1, D-99, and DH-2), each using various 3/16-inch, 1/4-inch, or 5/16-inch diameter nozzles.

Water temperature and ambient stream velocity outside the nozzle are two of several factors that are known to affect the intake efficiency of bag samplers. A regression curve was fitted to these data through LOWESS (locally weighted scatterplot smoothing), and a Kruskal-Wallis test was executed for the various samplers and nozzle sizes. Based on these results, there is no statistical evidence to indicate that water temperature and stream velocity have a noticeable effect on intake efficiency when the samplers are deployed under isokinetic conditions. Likewise, there is no statistical evidence to indicate that the type of bag sampler and nozzle diameter have a direct effect on intake efficiency.

Introduction

The Federal Interagency Sedimentation Project (FISP) includes representatives from the U.S. Geological Survey (USGS), U.S. Army Corps of Engineers, Bureau of Reclamation, and U.S. Department of Agriculture. The goal of this project is to standardize and advance sediment science among federal agencies. To address many critical water-related questions, representative water-constituent samples are collected using appropriate isokinetic samplers (Davis, 2005) and deployment techniques (Edwards and Glysson, 1999; Nolan and others, 2005; Gray and others, 2008; Federal Interagency Sedimentation Project, 2013). The USGS implemented a policy memorandum (U.S. Geological Survey, 2013) that matches intake efficiency guidance highlighted in the Federal Interagency Sedimentation Project (2013) memo. Suspended-sediment concentration (SSC) and sediment-associated water-quality constituent concentrations can be highly variable in stream cross sections, particularly when sand-size particles (0.0625 to 2 millimeters; Guy, 1970) are suspended in appreciable quantities. Consequently, samples representative of the flow throughout the cross section must be collected using depth- and width-integrated methods and isokinetic samplers. Isokinetic sampling means that water enters the nozzle of a sampler without accelerating or decelerating relative to stream velocity outside the sampler nozzle, often referred to as the "ambient velocity" of the stream. The measure of isokinetic sampling is the intake efficiency (IE), which is defined as the ratio of the velocity through the nozzle entrance (Vn) to the ambient stream velocity (V): IE=Vn/V, where Vn and V are averaged over the sample time and depth for each specific sample. The IE of every FISP bag sampler is confirmed under controlled conditions in tow tank tests at the USGS Hydrologic Instrumentation Facility and confirmed to be within 0.9 and 1.1 at velocities between 3 and 4 feet per second (ft/s) at laboratory temperature before the sampler is released for field use.

Isokinetic sampler performance on derived sediment concentrations is important. If flow decelerates as it enters the nozzle (IE less than [<] 1, subisokinetic), the sample SSC will tend to be biased high; if flow accelerates as it enters the nozzle (IE greater than [>] 1, super efficient), the sample SSC will be biased low. Significant bias in derived sand-sized SSC is likely if samples are obtained under conditions where IE<0.75 or IE>1.25 (Federal Interagency Sedimentation Project, 2013; Edwards and Glysson, 1999). Under some field and deployment conditions (for example, tidal influence, stream velocity above/below approved sampler capabilities), it may not be possible to collect a sample with 0.75<IE<1.25, in which case it is particularly important to document the IE so that potential bias in sand concentrations can be considered while analyzing data (fig. 1). Depending on project objectives, it may be acceptable to collect non-isokinetic samples if the sand percentage of SSC has been determined to be negligible in prior analyses of samples collected at that site under similar flow conditions. In any case, IE should be tested, and the IE test data should be recorded with each environmental sampling effort.

Factors that affect the IE of isokinetic samplers include accurate nozzle area, accurate stream velocity assessment, water temperature, transit rate of the sampler, and the sample volume relative to that of the sample container. IE tends to decrease as stream velocities decrease from about 4 to 2 ft/s (Davis, 2001), depending on the type of sampler, nozzle size, transit rate, and stream temperature. At low velocities, where sands are not transported (at or less than 2 ft/s), substantial concentrations of sand are unlikely, thus non-isokinetic sampling has limited influence on the accuracy of SSCs and sediment-associated water-quality constituent concentrations.

Decreasing stream temperatures tend to cause decreasing sampler IEs because friction losses increase through the sampler nozzle as fluid viscosity increases. Tests of FISP samplers are typically conducted at water temperatures between about 24 °C and 29 °C (75 °F and 85 °F), which is in the warmer range of most field sampling conditions. Cold-water tests indicate that the US D-96 performs sub-isokinetically (IE<0.9) at temperatures less than about 10 °C (50 °F) at velocities less than about 3.7 ft/s for all nozzle sizes (Davis, 2001).

Sample volumes should not exceed recommended sample container capacities or IE will decline rapidly as described by Szalona (1982) and Davis (2001). Sampling up to full-bag capacity did not affect IE in extensive laboratory tests at warm temperatures and in limited field tests in larger rivers.

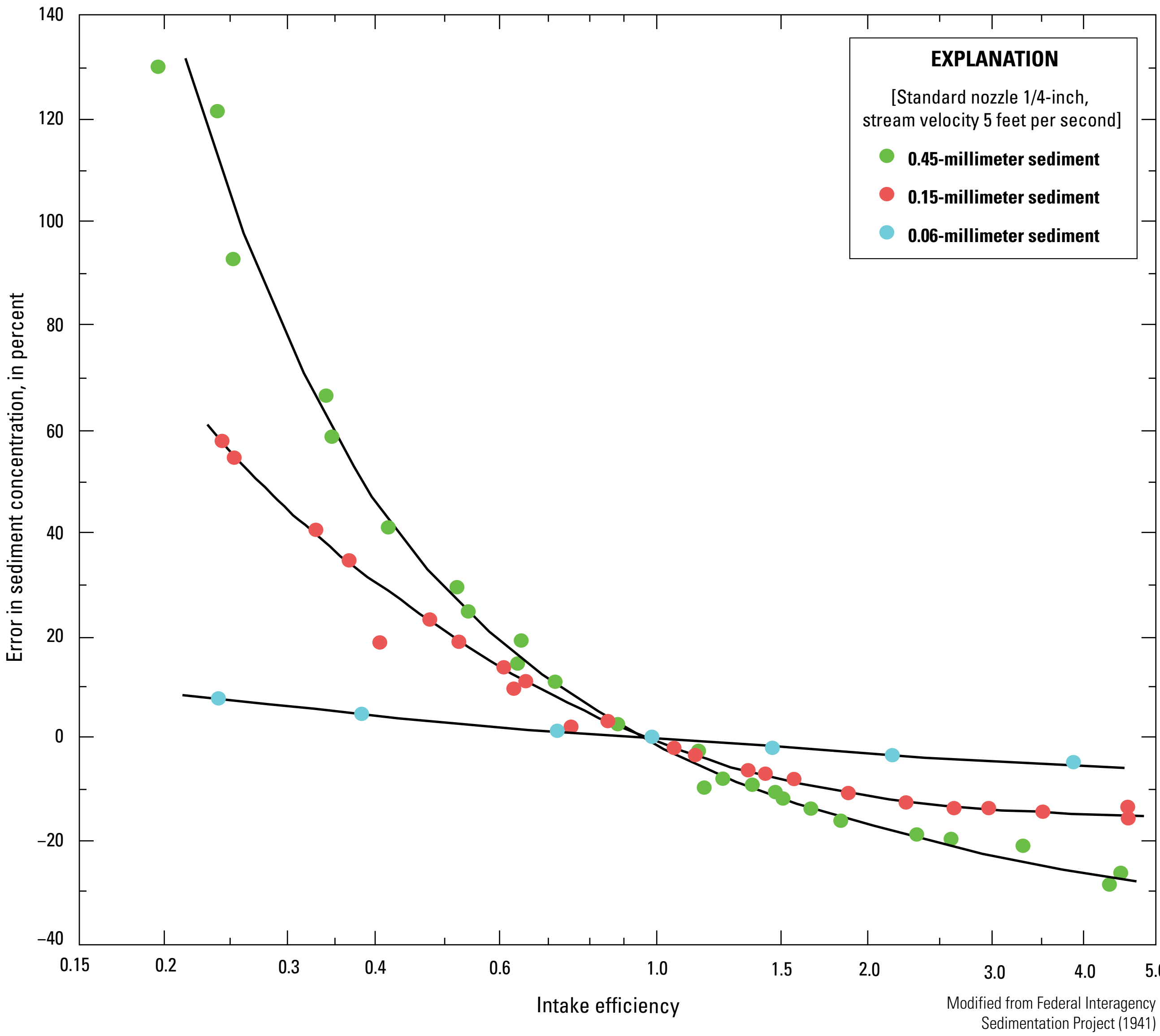
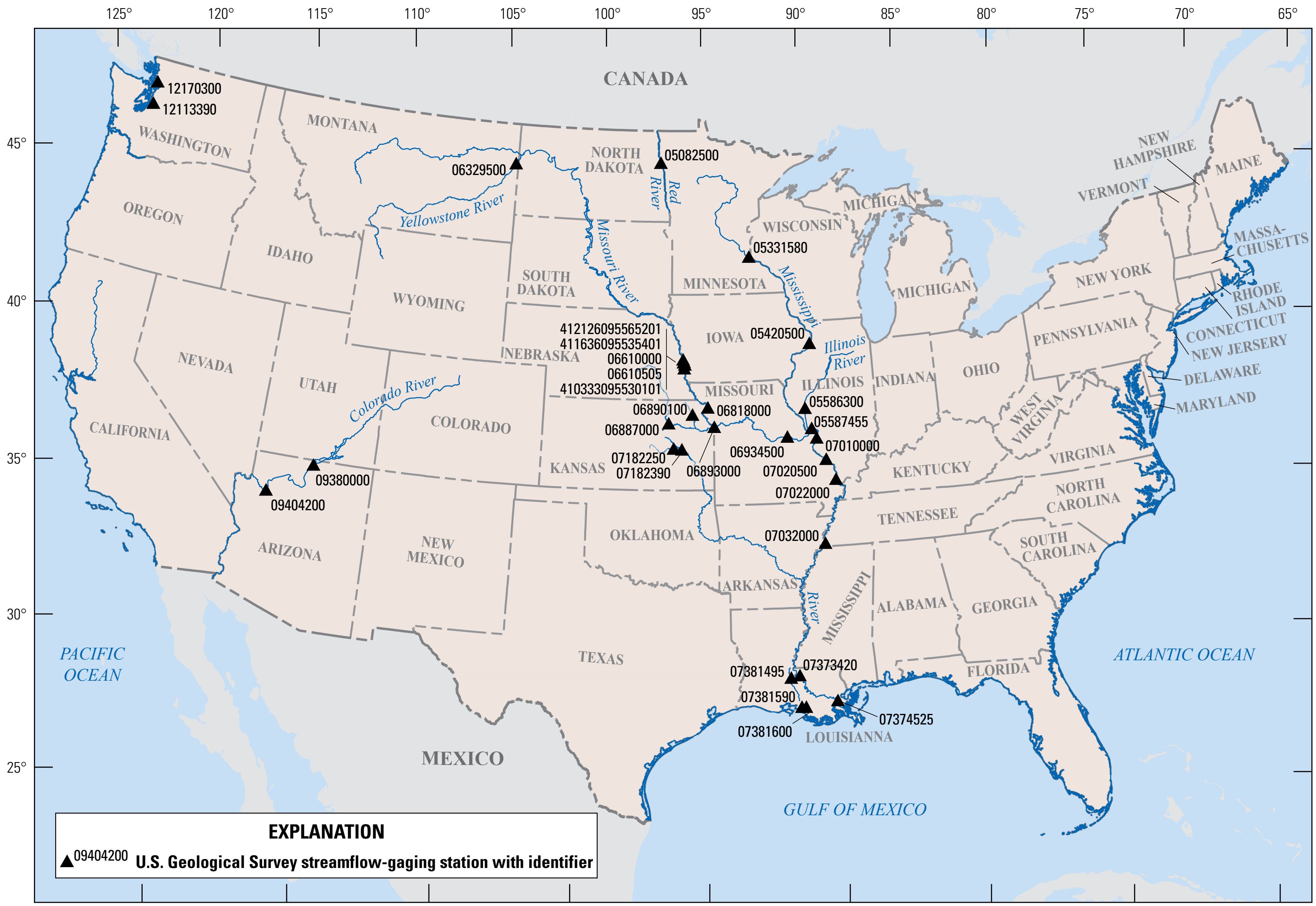


Figure 1. Errors in suspended-sediment concentration for variable nonisokinetic sampling conditions for four sediment sizes, for flow velocity of 5 feet per second. Figure from Sabol and Topping (2012), Gray and others (2008), based on data from Federal Interagency Sedimentation Project (1941).

However, Sabol and Topping (2012) reported that sample volume also can affect IE before reaching container capacity in the turbulent riverine environment of their tests. Additional data have been collected and are presented in this report to further evaluate the IE of FISP samplers.

Purpose and Scope

The purpose of this report is to evaluate the intake efficiency of FISP bag samplers and associated nozzle sizes, and to compare the results to ambient stream velocity and water temperature to determine if these physical variables affect intake efficiency. The data and analyses in this report offer supplemental information to help determine whether FISP bag sampling procedures should continue as outlined in the current USGS policy (Federal Interagency Sedimentation Project, 2013). The scope of this report is limited to 31 USGS streamflow-gaging stations (U.S. Geological Survey, 2022a; fig. 2; table 1.1; fig. 1.1) across the contiguous United States where data were collected between July 15, 2013, and June 17, 2020, using the FISP approved bag samplers (US D-96, D-96-A1, D-99, and DH-2) equipped with 3/16-inch (in.), 1/4-in., or 5/16-in. diameter nozzles. The scope of this report is focused on empirical data reporting and analysis. These data can be further interpreted from the hydraulic analysis of intake efficiency, as in Sabol and Topping (2012).



Base from U.S. Geological Survey digital data, 1:1,000,000
Albers Equal-Area Conic projection
Standard parallels 29°30′ N. and 45°30′ N.
Central meridian 96°00′ W.
North American Datum of 1983

0 250 500 MILES
0 250 500 KILOMETERS

Figure 2. Map of the 31 U.S. Geological Survey streamflow-gaging stations where intake efficiency data were collected.

Methods

Field methods for collecting the data necessary to calculate IE are presented in this section and follow the steps outlined in the memorandum from the Federal Interagency Sedimentation Project (2013). Data are available from the U.S. Geological Survey National Water Information System database (U.S. Geological Survey, 2022a) by using the station identifiers shown in figure 2. Statistical tests used to analyze the data are also presented.

Mostly excerpted from the memorandum (Federal Interagency Sedimentation Project, 2013), the information needed and methods are as follows:

IE tests require knowledge of the intake nozzle size, and measurements of the following: (a) the duration of time the sampler nozzle is submerged (in seconds), (b) sample volume (in milliliters), and (c) average stream velocity at the sampler intake during sample collection (in feet per second).

A large, graduated pitcher or cylinder was used to measure sample volume. Maximizing the accuracy of each of these measurements is important because the computed IE requires accurate values from each of these measurements.

The method used to perform an IE test follows:

1. Select the location of the IE-test vertical from one of the planned sampling stations. The IE-test vertical preferably will have velocity characteristics similar to those of the majority of sampling stations; alternatively, one may opt to test for maximum isokinetic transit rate at the deepest, fastest section of the stream cross section (or measure the IE at each sampled section to represent the entire composite or discrete sample). It is important to note the IE-test vertical location.

2. Record the water temperature and time.

3. Prepare the bag sampler as described in the sampler manual and deploy through the IE-test vertical as for a regular depth-integrated sample, as described in Edwards and Glysson (1999).

4. Record the duration of sampler nozzle submergence (the duration of the IE-test sample being collected) to the nearest second.

5. Remove the bag and carefully measure the IE-test sample volume by decanting to a graduated cylinder. The IE-test sample subsequently should be discarded. Laboratory analysis of the IE-test sample is not required; however, visual examination of the IE-test sample for the presence of sand is recommended.

6. Measure the velocity in the IE-test vertical at or near the IE-test time. Measure the velocity using a standard cup-meter or an acoustic Doppler current profiler (ADCP) deployed from the sampling vessel or suspended in the sampling streamline. The average velocity at the IE-test vertical also could be derived from an ADCP moving-boat active velocity reading (particularly for steady flow conditions). The velocity should be the average for the depth over which the IE was tested. Rather than live readings from the ADCP, it is preferred to use the Equal-Discharge-Increment program in QRev (the ADCP data processing software; U.S. Geological Survey, 2022b), which will compute the average stream velocity using an expanded array of ensembles.

7. Repeat steps 3–6 twice (for a total of three measurements) at the same location, if safe and practical. Repeating velocity measurements (step 6) is preferred, but if velocity is steady and without notable turbulence, a single velocity measurement for the three tests is adequate. The individual velocity measurements should be recorded.

8. Compute the IE for each test using the following equation below (Federal Interagency Sedimentation Project, 2013).

   The IE is computed using the following equation:

$$IE = K \times \left(\frac{V}{D}\right) / SV \tag{1}$$

where

- K is indexed to nozzle diameter (parameter code 72220; U.S. Geological Survey, 2022a) equal to 0.1841 for 3/16 in., 0.1036 for 1/4 in., 0.0663 for 5/16 in.;
- V is volume, in milliliters (parameter code 72218; U.S. Geological Survey, 2022a);
- D is duration, in seconds (parameter code 72217; U.S. Geological Survey, 2022a); and
- SV is stream velocity, in feet per second (parameter code 72196; U.S. Geological Survey, 2022a).

9. If the average IE is within 0.75<IE<1.25 and each individual IE measurement is within 0.7<IE<1.3, then proceed with collecting the environmental sample(s).

10. If the average IE is not within 0.75<IE<1.25 and (or) each individual IE measurement is not within 0.7<IE<1.3, then proceed with the following:

    i. if suspended sand has been documented as absent in prior analyses of samples collected at the site under similar conditions, then clearly note this information and proceed with collecting the environmental sample(s);

    ii. if suspended sand may be present in the SSC, then consider replacing the sampler nozzle and (or) sampler and repeat steps 3–8; or

iii. if the average IE is not within 0.75<IE<1.25, then still collect the environmental sample(s), note the IE, document the site and equipment conditions, document why alternative equipment could not be used, and reconsider the operational approach to sampling at the site.

The Kruskal-Wallis (KW) test is a nonparametric statistical test used to determine if the centers of several independent groups of data differ (Helsel and others, 2020). The null hypothesis is that the medians of the groups are identical, whereas the alternative hypothesis is that at least one group median differs from the others. This test is used in lieu of the analysis of variance (ANOVA) because the distribution of the intake efficiency dataset is unknown (that is, it is not implied whether or not the data follow any particular type of distribution, such as a normal distribution, which is required for ANOVA). The KW test yields an H statistic that follows a chi-squared distribution at n–1 degrees of freedom (where n is the number of groups included in the analysis). A KW test in Python, utilizing the package scipy.stats.kruskal (https://docs.scipy.org/doc/scipy/reference/generated/scipy.stats.kruskal.html) on the appropriate datasets, results in an H statistic and p-value. The p-value describes quantitatively the proportion of the chi-square distribution that equals or exceeds the H test statistic and is ultimately compared to an α value of 0.05. If $p>\alpha=0.05$, the null hypothesis is not rejected because there is not enough evidence to indicate that the medians of any of the groups differ. However, if $p<\alpha=0.05$, the null hypothesis is rejected, meaning there is evidence to indicate that the median of at least one of the groups differs from the others to some level of significance. In this case, a post-hoc test would then be required to determine what specific groups deviate from the others (Helsel and others, 2020).

Locally weighted scatterplot smoothing (LOWESS) is a rigorous mathematical procedure that fits a regression curve to a set of data points on a scatterplot (Helsel and others, 2020). LOWESS regression is helpful in identifying trends in data that are not apparent at first glance. For this report, identification of trends in data was accomplished using Python, in particular, the package statsmodels.api.nonparametric.lowess (https://www.statsmodels.org/stable/generated/statsmodels.nonparametric.smoothers_lowess.lowess.html) on the appropriate datasets.

Intake Efficiency Results and Discussion

Analyzing these datasets first requires knowledge of the number of measurements recorded and the conditions in which the samples were obtained. Before conclusions can be drawn pertaining to IE of different samplers and nozzle diameters, extent of each dataset needs to be considered. For example, note the US D-96 bag sampler (217 samples) and samplers with a nozzle diameter of 3/16-in. (262 samples) possess the most data, whereas the US D-96 A1 bag sampler (18 samples) and samplers with a nozzle diameter of 5/16-in. (17 samples) possess the least data (tables 1–2; figs. 3–9). The more data available, the more accurate the statistical inferences extrapolated from these data will be (and vice versa). Therefore, this information is important when considering these datasets (table 1.2) and the analysis that follows. Stations that may have data but were not entered into the USGS National Water Information System database were not used (U.S. Geological Survey, 2022a). Also, some data may have been averaged before entered into USGS National Water Information System. Lastly, outliers that did not make physical sense or were verified as erroneous by field staff were excluded.

The median IE values categorized by sampler type are virtually the same (0.940–0.967), as well as those categorized by nozzle diameter (0.914–0.951) (table 1; fig. 3). The lower and upper quartiles of these datasets, in tandem with the average, median, and sample standard deviation, indicate that most of the IE values are tightly centered around 0.95 for samplers equipped with the smaller nozzle sizes (3/16-in. and 1/4-in., with average values of 0.957 and 0.938, respectively)

Table 1. Summary of intake efficiency data categorized by bag sampler type and nozzle diameter.

[in., inch]

Intake efficiency	Bag sampler				Nozzle diameter		
	US D-96	**US D-96-A1**	**US D-99**	**US DH-2**	**3/16 in.**	**1/4 in.**	**5/16 in.**
Number of measurements	217	18	54	80	262	90	17
Average	0.938	0.946	0.940	0.988	0.957	0.938	0.895
Minimum	0.529	0.505	0.716	0.502	0.502	0.529	0.505
Maximum	1.636	1.351	1.243	1.668	1.668	1.343	1.351
25th percentile	0.884	0.773	0.851	0.906	0.893	0.795	0.835
Median	0.940	0.946	0.937	0.967	0.951	0.941	0.914
75th percentile	1.000	1.088	1.027	1.070	1.008	1.068	0.982
Standard deviation	0.158	0.231	0.114	0.149	0.140	0.184	0.200

Table 2. Summary of intake efficiency data categorized by stream velocity and water temperature.

[°C, degree Celsius; ft/s, foot per second; ≤, less than or equal to; >, greater than; <, less than; ≥, greater than or equal to]

Intake efficiency	Stream velocity (ft/s)			Water temperature (°C)		
	≤2.0	>2.0 to <3.7	≥3.7	≤10	>10 to <20	≥20
Number of measurements	7	56	306	124	88	157
Average	0.826	0.982	0.947	0.95	0.958	0.944
Minimum	0.601	0.646	0.502	0.502	0.505	0.539
Maximum	1.036	1.636	1.668	1.347	1.636	1.668
25th percentile	0.632	0.866	0.883	0.883	0.878	0.871
Median	0.926	0.952	0.947	0.95	0.944	0.945
75th percentile	0.976	1.020	1.015	1.012	1.034	1.012
Standard deviation	0.195	0.196	0.145	0.138	0.187	0.149

but exhibit a slightly negative deviation from this behavior (that is, these values become centered around a value <0.95) for samplers with 5/16-in. (average=0.895) nozzle diameters. However, the range of these values is more substantial for smaller nozzle sizes; the gap is wider between minimum and maximum intake efficiency values for all sites and measurements as the width of the nozzle decreases (but this could be because more data are available for the smaller nozzle sizes).

A KW test was computed for two distinct groups of IE values: those categorized by sampler type and by nozzle size (fig. 3). Because p=0.052 for the sampler group (fig. 3*A*) and p=0.294 for the nozzle diameter group (fig. 3*B*), both are greater than the specified cutoff value of α=0.05 and it is clear that the statistical evidence from the KW test is not strong enough to reject the null hypothesis (that is, the medians of the various samplers and nozzle diameters do not differ significantly despite any indication of this in tables 1–2 and fig. 3).

The range of stream velocities and water temperatures for the samples were 1.11 to 9.80 ft/s and −0.1 to 30.1 °C, respectively (tables 1.3 and 1.4, respectively). The IE values categorized by stream velocity and water temperature also provide insight into the IEs of the samplers (table 2; figs. 4–9). The IEs corresponding to stream velocities less than or equal to 2 ft/s are, in general, lower than those greater than 2 ft/s, indicating that these samplers do not perform as well under slower stream velocities (but this could be because the least number of samples are in the less than or equal to 2 ft/s category). These results reconfirm findings initially documented in Davis (2005), which are that samplers do not perform as well under slower streamflow conditions. However, variability in IE is larger when the stream velocity is greater than or equal to 3.7 ft/s. For water temperature, IE values were relatively consistent across the spectrum, but variability appears to be greater with higher water temperatures than with temperatures less than or equal to 10 °C (table 2; fig. 4). A LOWESS curve was generated for IE versus stream velocity (fig. 5*A*) and IE versus water temperature (fig. 5*B*). A definitive trend is not evident in the regression for stream velocity and water temperature, which indicates that neither of these variables in the available datasets have a noticeable effect on IE.

The plots of stream velocity and water temperature versus IE are presented in figures 6–7 and figures 8–9, respectively. IE data categorized by bag sampler type are shown in figures 6 and 8, whereas IE data categorized by nozzle diameter are shown in figures 7 and 9. These plots give further support for the results stated previously.

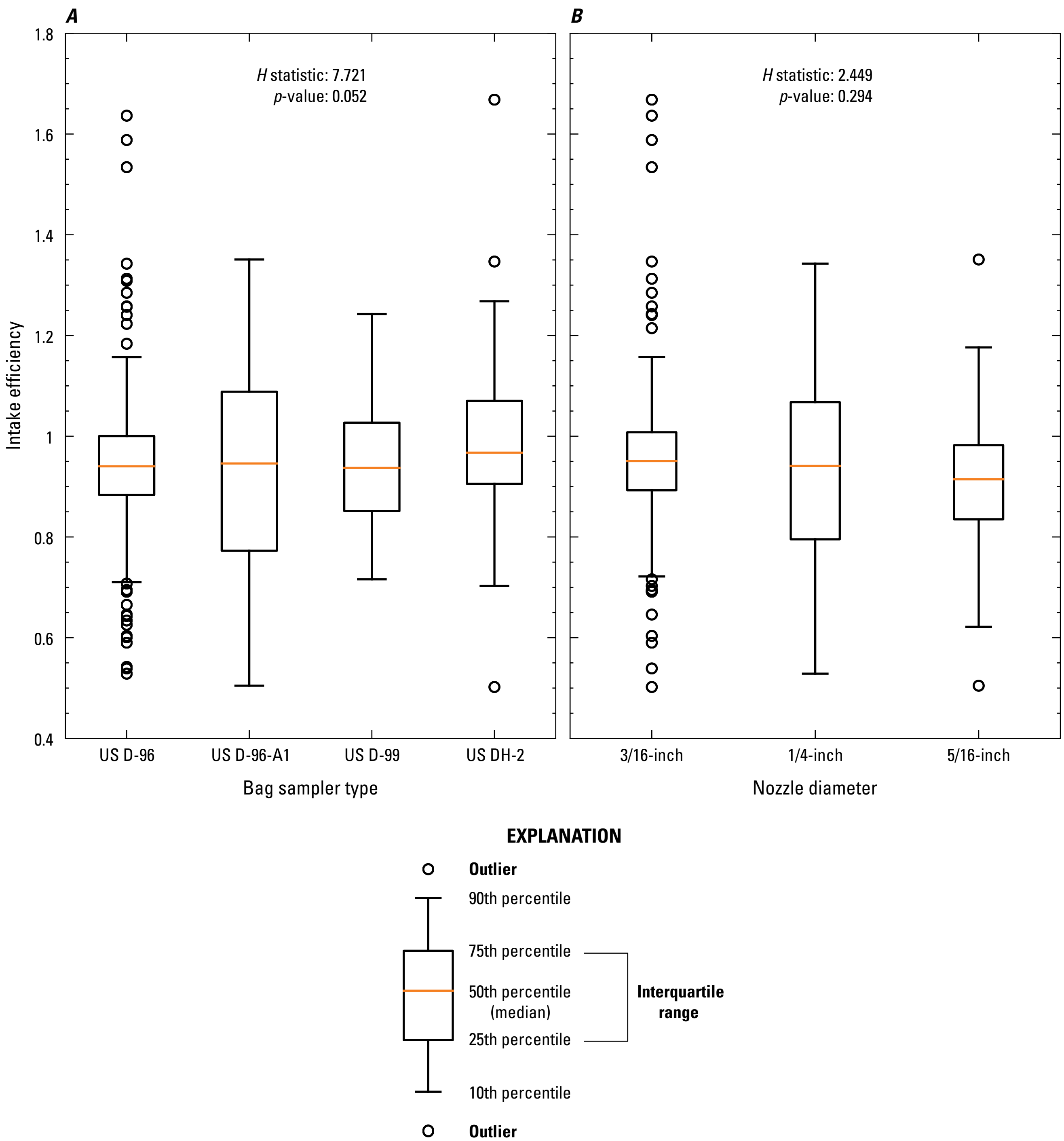


Figure 3. Intake efficiency values for all samplers and nozzle sizes. *A*, Sorted by bag sampler type. *B*, Sorted by nozzle diameter. The *H* statistic and *p*-value are reported from the Kruskal-Wallis test.

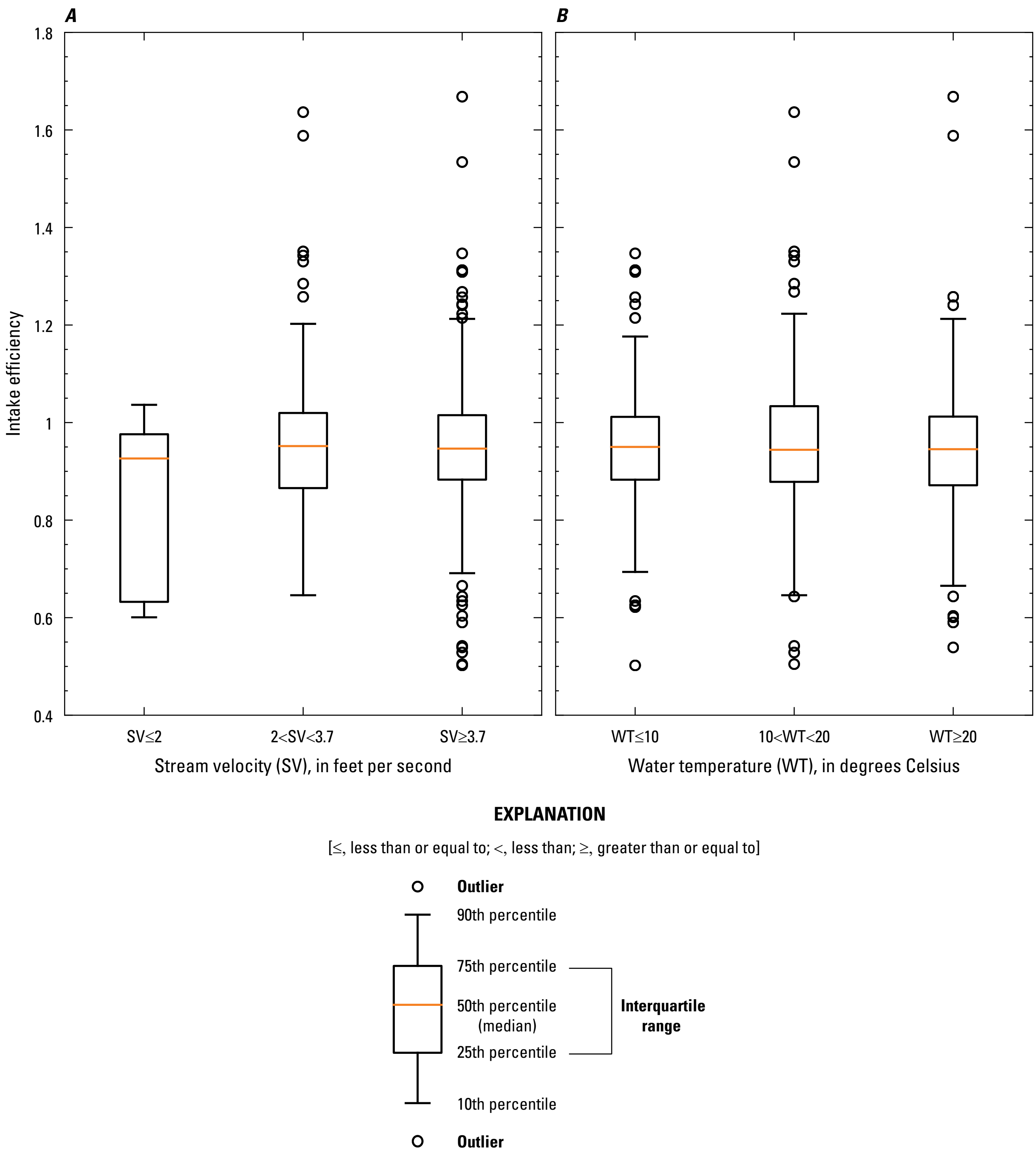
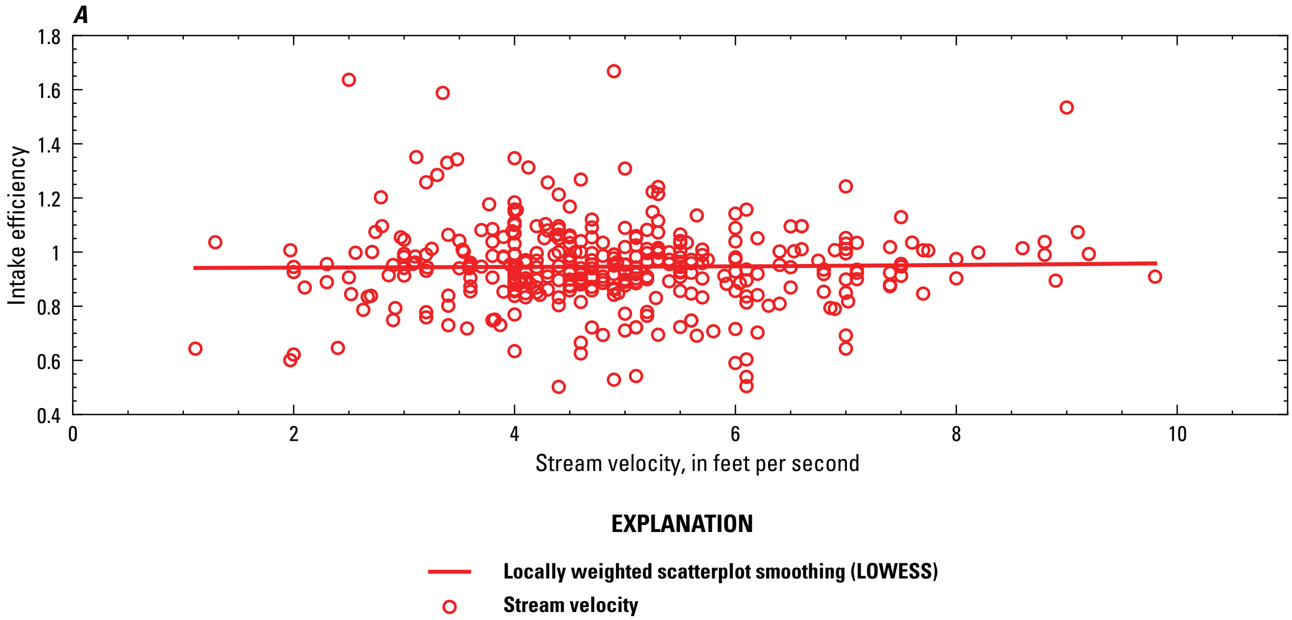


Figure 4. Intake efficiency values sorted by *A*, stream velocity, and *B*, water temperature.



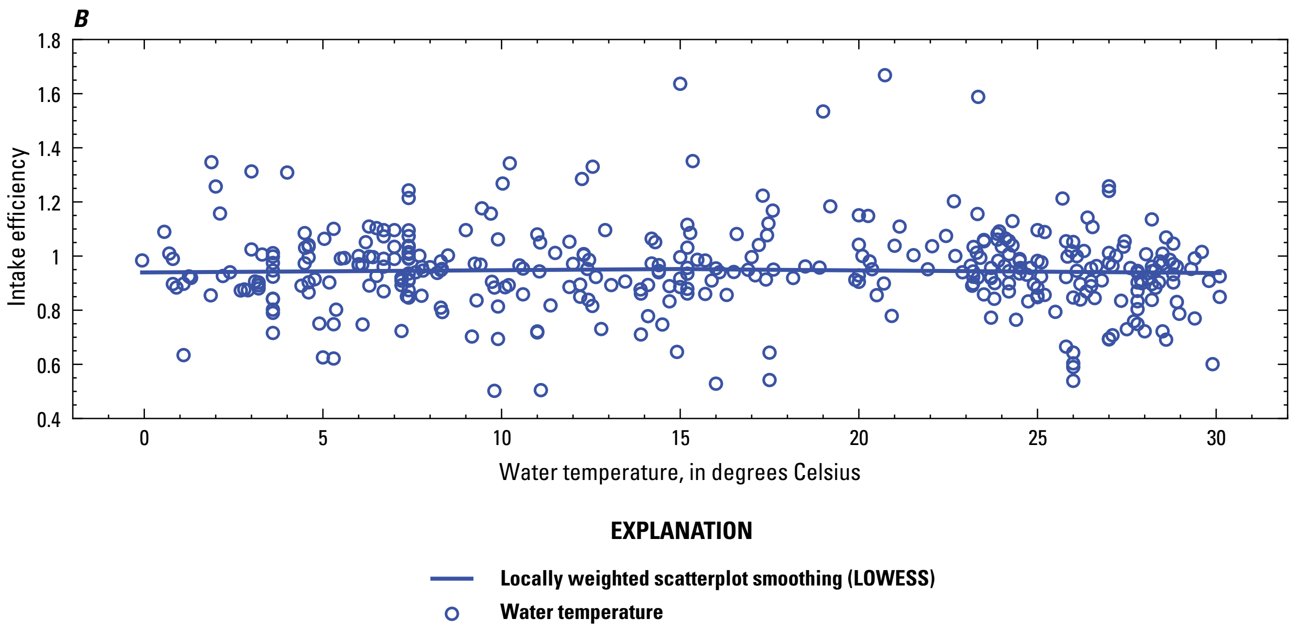


Figure 5. Locally weighted scatterplot smoothing (LOWESS) regression plots for *A*, intake efficiency (IE) versus stream velocity (SV), and *B*, IE versus water temperature (WT).

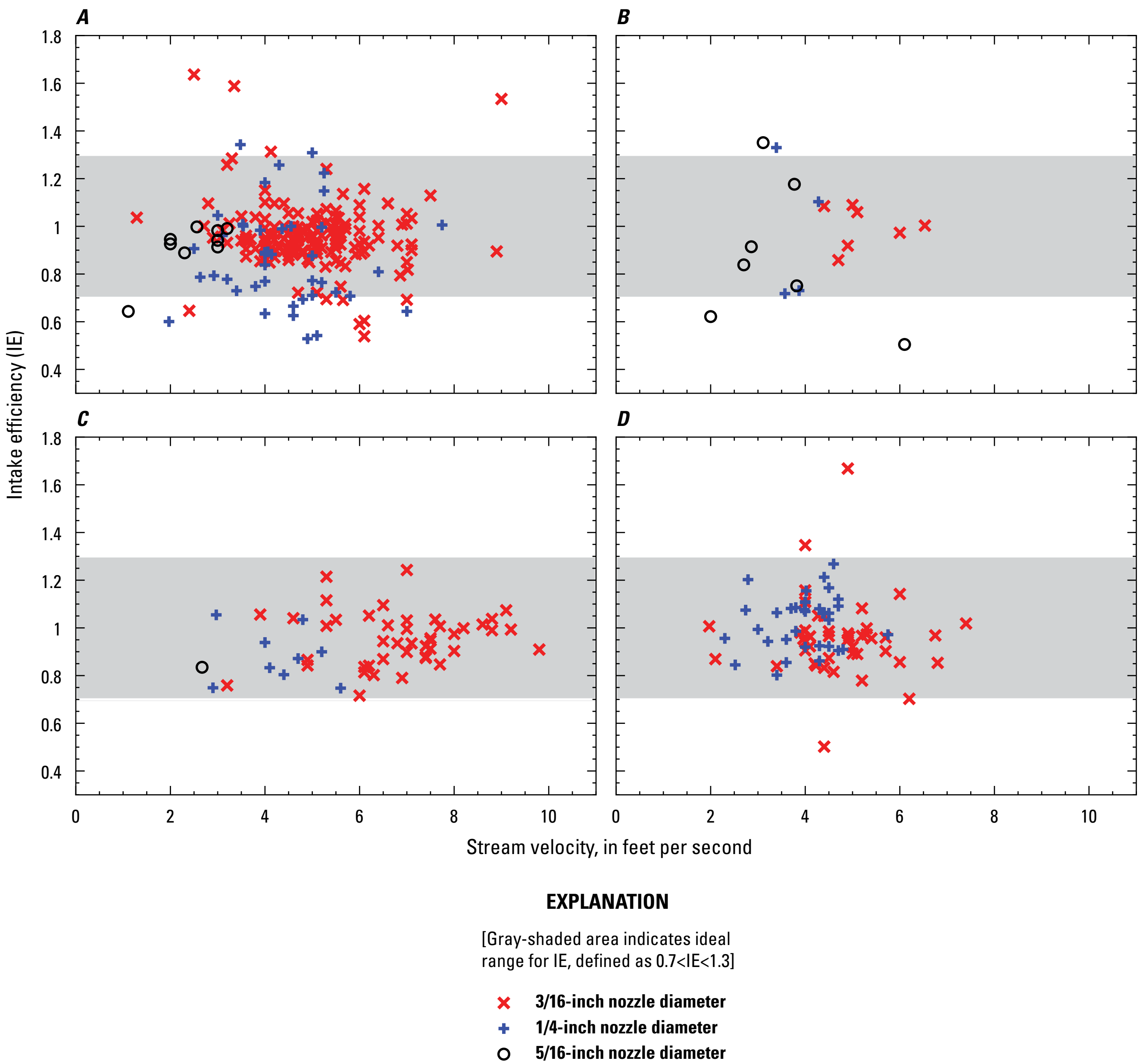


Figure 6. Comparison of intake efficiency and stream velocity for different bag samplers. *A*, US D-96. *B*, D-96-A1. *C*, D-99. *D*, DH-2.

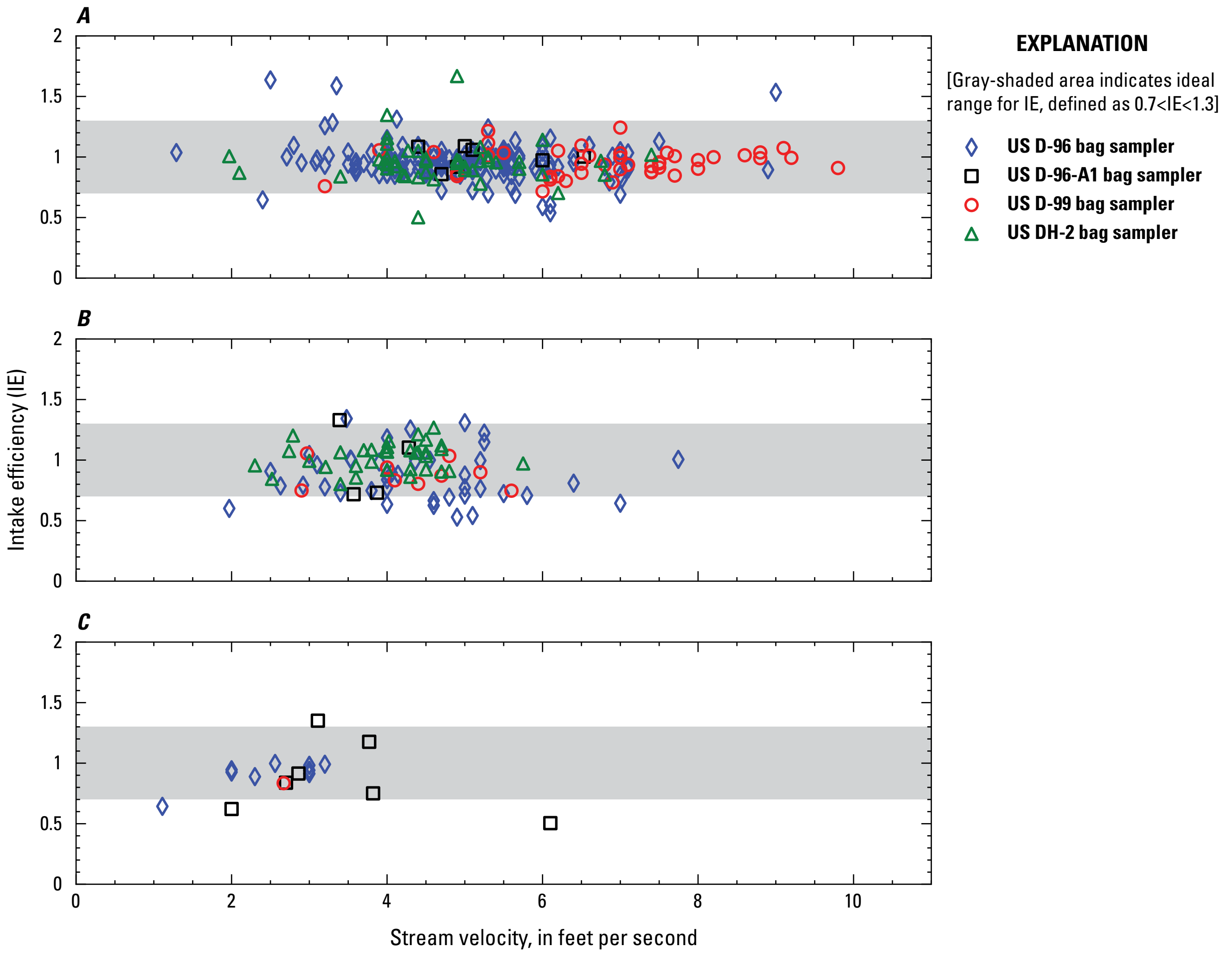


Figure 7. Comparison of intake efficiency and stream velocity for different nozzle diameters. *A*, 3/16-inch. *B*, 1/4-inch. *C*, 5/16-inch.

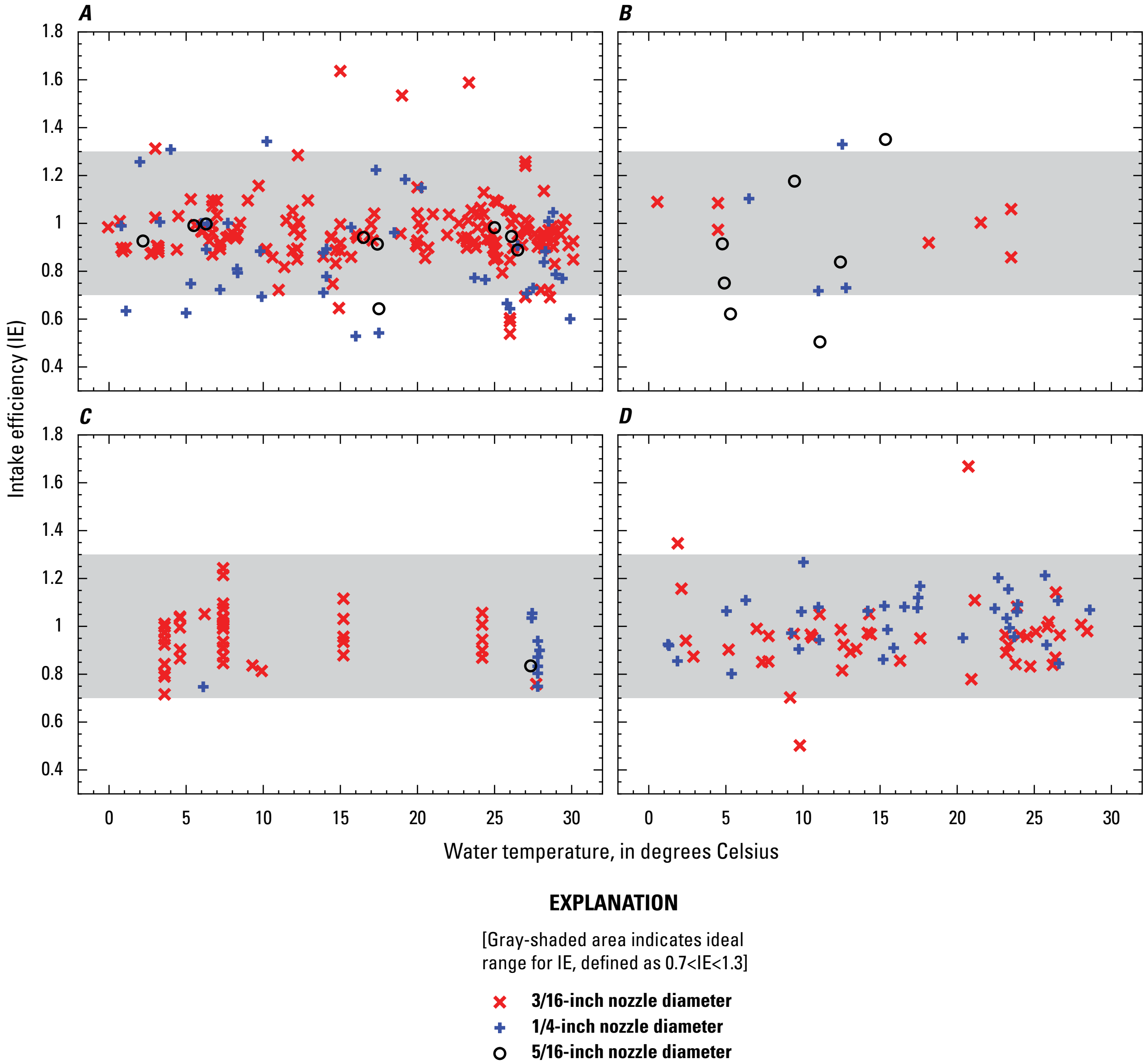


Figure 8. Comparison of intake efficiency and water temperature for different bag samplers. *A*, US D-96. *B*, D-96-A1. *C*, D-99. *D*, DH-2.

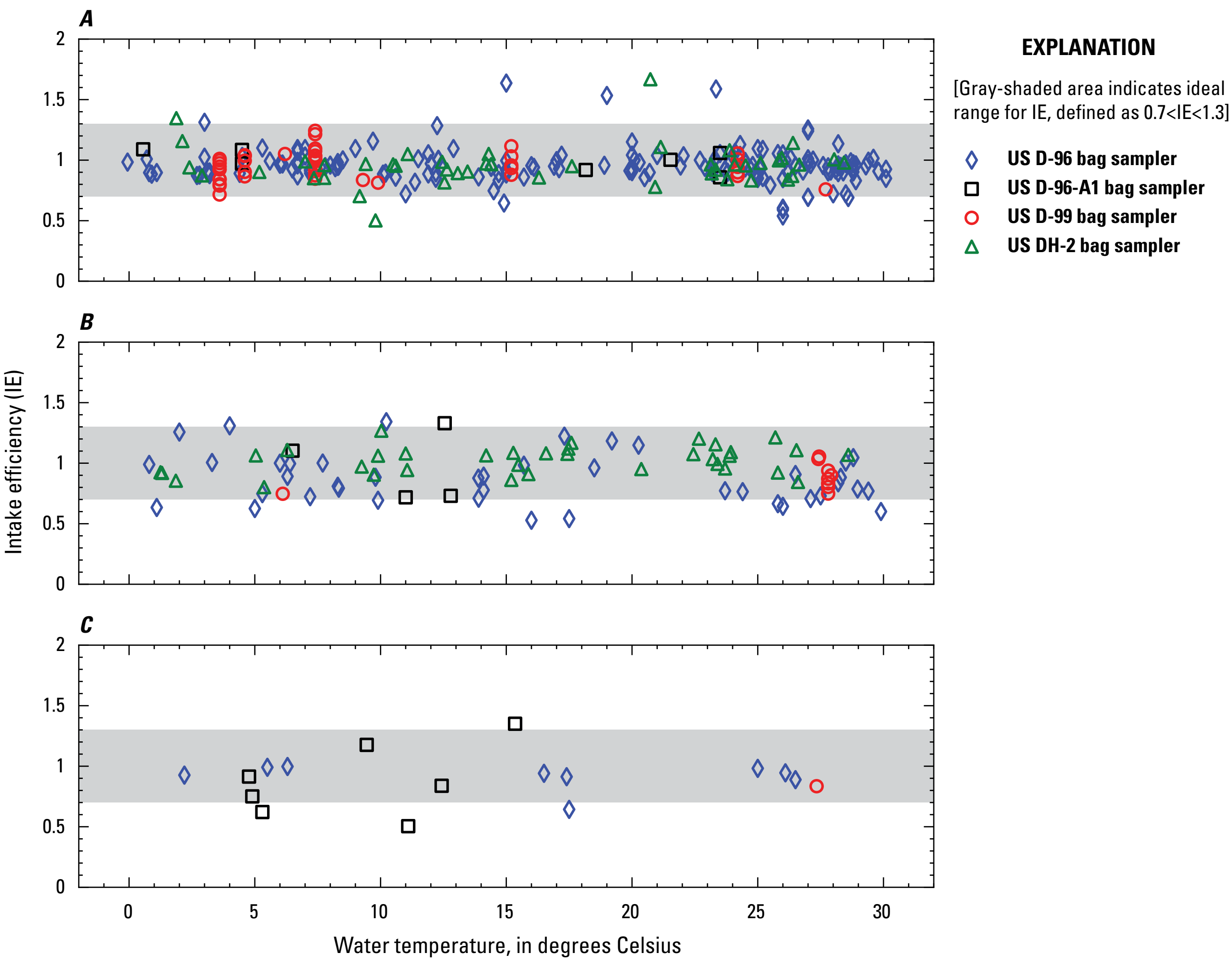


Figure 9. Comparison of intake efficiency and water temperature for different nozzle diameters. *A*, 3/16-inch. *B*, 1/4-inch. *C*, 5/16-inch.

Summary

It is important to ensure that the Federal Interagency Sedimentation Project bag samplers perform isokinetically under all tested and approved conditions and collect samples that are representative of the stream or river cross-section. An isokinetic sample means that water enters the nozzle of a sampler without accelerating or decelerating relative to streamflow velocity at the sampler nozzle. Factors that affect the intake efficiency (IE) of isokinetic samplers include sampler type and nozzle design, stream velocity, water temperature, sampler orientation relative to the flow, and the sample volume relative to that of the sample container. If flow decelerates as it enters the nozzle (IE less than [<] 1, subisokinetic), the sample suspended-sediment concentration (SSC) will tend to be biased high; if flow accelerates as it enters the nozzle (IE greater than [>] 1, super efficient), the sample SSC will be biased low. Significant bias in derived sand-sized SSC is likely if samples are obtained under conditions where IE<0.75 or IE>1.25.

Based on the available data, with the US D-96, D-96-A1, D-99, and DH-2 bag samplers, in tandem with the various nozzle diameters (3/16-inch, 1/4-inch, and 5/16-inch), 97 percent of the samples are within 0.7<IE<1.3 recommended to proceed with collecting the environmental sampling procedure outlined by the Federal Interagency Sedimentation Project. The IE values categorized by bag sampler type and nozzle diameter show similar IEs as one another (average values range between 0.895 and 0.988). Water temperature and stream velocity are two of several factors that are known to affect the IE of bag samplers. However, based on these data, no statistical evidence indicates that either variable noticeably affects IE. Likewise, no statistical evidence indicates that the type of bag sampler and nozzle diameter directly affects IE. For future deployment of Federal Interagency Sedimentation Project samplers, it is important that the appropriate protocol is followed so that IE is close to 1 (ideally, 0.7<IE<1.3) and representative samples from the stream cross-section are obtained.

Acknowledgments

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Appendix 1. Intake Efficiency Field Data and Additional Figure

Table 1.1. Site number, name, and drainage area for sites in study area (U.S. Geological Survey, 2022).

[mi², square mile; N/A, data not available]

Site number	Site name	Drainage area (mi²)
05082500	Red River of the North at Grand Forks, North Dakota	30,100
05331580	Mississippi River below Lock and Dam #2 at Hastings, Minnesota	37,100
05420500	Mississippi River at Clinton, Iowa	85,600
05586300	Illinois River at Florence, Illinois	26,870
05587455	Mississippir River below Grafton, Illinois	171,300
06329500	Yellowstone River near Sidney Montana	69,099
06610000	Missouri River at Omaha, Nebraska	322,800
06610505	Missouri River near Council Bluffs, Iowa	322,840
06818000	Missouri River at St. Joseph, Missouri	426,500
06887000	Big Blue River near Manhattan, Kansas	9,640
06890100	Delaware River near Muscotah, Kansas	431
06893000	Missouri River at Kansas City, Missouri	484,100
06934500	Missouri River at Hermann, Missouri	522,500
07010000	Mississippi River at St. Louis, Missouri	697,000
07020500	Mississippi River at Chester, Illinois	708,600
07022000	Mississippi River at Thebes, Illinois	713,200
07032000	Mississippi River at Memphis, Tennessee	932,800
07182250	Cottonwood River near Plymouth, Kansas	1,740
07182390	Neosho River at Neosho Rapids, Kansas	2,753
07373420	Mississippi River near St. Francisville, Louisiana	1,125,300
07374525	Mississippi River at Belle Chasse, Louisiana	1130000
07381495	(COE) Atchafalaya River at Melville, Louisiana	93,316
07381590	Wax Lake Outlet at Calumet, Louisiana	N/A
07381600	Lower Atchafalaya River at Morgan City, Louisiana	N/A
09380000	Colorado River at Lees Ferry, Arizona	111,800
09404200	Colorado River above Diamon Creek near Peach Springs, Arizona	149,316
12113390	Duwamish River at Golf Course at Tukwila, Washington	461
12170300	Stillaguamish River near Stanwood, Washington	662
410333095530101	Missouri River near La Platte, Nebraska	N/A
411636095535401	Missouri River at Freedom Park Omaha, Nebraska	N/A
412126095565201	Missouri River at NP Dodge Park at Omaha, Nebraska	N/A

Table 1.2. Intake efficiency data for each site and sample (U.S. Geological Survey, 2022).

[ID, identification; °C, degree Celsius; ft/s, feet per second; in., inch]

Site number	Site ID (fig. 1.1)	Date	Time	Water temperature (°C)	Stream velocity (ft/s)	Sampler type	Nozzle diameter (in.)	Nozzle velocity	Intake efficiency
05082500	1	20140414	1300	2.4	4.00	DH-2	3/16	3.760	0.940
05082500	1	20140429	1150	7.0	4.00	DH-2	3/16	3.958	0.990
05082500	1	20140514	1020	10.6	3.96	DH-2	3/16	3.777	0.954
05082500	1	20140522	1050	13.5	4.00	DH-2	3/16	3.623	0.906
05082500	1	20140610	1040	20.4	3.60	DH-2	1/4	3.425	0.951
05082500	1	20140710	1115	23.3	4.02	DH-2	1/4	4.645	1.155
05082500	1	20140731	1050	23.4	3.00	DH-2	1/4	2.981	0.994
05082500	1	20150519	1040	11.1	3.21	DH-2	1/4	3.028	0.943
05082500	1	20150603	1120	16.6	3.70	DH-2	1/4	4.001	1.081
05082500	1	20150624	1130	22.4	2.74	DH-2	1/4	2.944	1.074
05082500	1	20150728	1130	26.6	2.52	DH-2	1/4	2.129	0.845
05082500	1	20160809	1110	23.7	2.30	DH-2	1/4	2.199	0.956
05331580	2	20140515	1200	12.3	3.30	D-96	3/16	4.240	1.285
05331580	2	20160512	1040	14.9	2.40	D-96	3/16	1.550	0.646
05331580	2	20170620	1100	22.1	1.29	D-96	3/16	1.337	1.036
05420500	3	20130716	1100	27.0	3.20	D-96	3/16	4.025	1.258
05420500	3	20140429	1030	10.2	3.48	D-96	1/4	4.672	1.343
05420500	3	20140623	1030	21.9	4.02	D-96	3/16	3.824	0.951
05420500	3	20140709	1130	23.3	3.25	D-96	3/16	3.290	1.012
05420500	3	20140721	1030	23.3	3.35	D-96	3/16	5.320	1.588
05586300	4	20180605	1110	26.4	2.10	DH-2	3/16	1.825	0.869
05586300	4	20180619	1130	28.0	1.97	DH-2	3/16	1.983	1.007
05586300	4	20180703	1100	29.0	2.63	D-96	1/4	2.069	0.787
05586300	4	20180717	1115	29.9	1.97	D-96	1/4	1.183	0.601
05587455	5	20160516	1404	17.4	3.00	D-96	5/16	2.740	0.913
05587455	5	20160620	1420	28.2	4.00	D-96	1/4	3.352	0.838
05587455	5	20160726	1358	29.4	4.00	D-96	1/4	3.078	0.770
05587455	5	20160801	1404	28.8	3.00	D-96	1/4	3.138	1.046
05587455	5	20160906	1550	25.0	3.00	D-96	5/16	2.947	0.982
05587455	5	20161107	1436	14.1	3.20	D-96	1/4	2.490	0.778
05587455	5	20161212	1439	2.2	2.00	D-96	5/16	1.853	0.926
05587455	5	20170313	1536	5.5	3.20	D-96	5/16	3.171	0.991
05587455	5	20170417	1632	16.5	3.00	D-96	5/16	2.824	0.941
05587455	5	20180402	1503	6.3	2.56	D-96	5/16	2.554	0.998
05587455	5	20180604	1350	26.1	2.00	D-96	5/16	1.891	0.945
05587455	5	20180618	1338	26.5	2.50	D-96	1/4	2.266	0.907
05587455	5	20180709	1426	28.5	3.53	D-96	1/4	3.561	1.009
05587455	5	20180904	1436	26.5	2.30	D-96	5/16	2.044	0.889
05587455	5	20181002	1148	18.5	3.10	D-96	1/4	2.981	0.962
05587455	5	20190325	1450	6.3	4.00	D-96	1/4	3.564	0.891
05587455	5	20190415	1418	9.8	4.00	D-96	1/4	3.535	0.884

Table 1.2. Intake efficiency data for each site and sample (U.S. Geological Survey, 2022).—Continued

[ID, identification; °C, degree Celsius; ft/s, feet per second; in., inch]

Site number	Site ID (fig. 1.1)	Date	Time	Water temperature (°C)	Stream velocity (ft/s)	Sampler type	Nozzle diameter (in.)	Nozzle velocity	Intake efficiency
05587455	5	20190430	1312	14.1	4.06	D-96	1/4	3.626	0.893
05587455	5	20190507	1406	14.4	4.00	D-96	3/16	3.780	0.945
05587455	5	20190529	1356	20.5	4.00	D-96	3/16	3.422	0.856
05587455	5	20190611	1418	24.8	3.08	D-96	3/16	2.946	0.956
05587455	5	20190625	1430	22.9	3.59	D-96	3/16	3.375	0.940
05587455	5	20190708	1502	28.3	3.60	D-96	3/16	3.414	0.948
05587455	5	20190722	1338	28.9	4.10	D-96	3/16	3.941	0.961
05587455	5	20190820	1332	28.2	3.60	D-96	3/16	3.459	0.961
06329500	6	20140528	1500	19.2	4.00	D-96	1/4	4.735	1.184
06329500	6	20140616	1530	17.5	5.10	D-96	1/4	2.764	0.542
06329500	6	20170530	1630	15.7	3.90	D-96	1/4	3.836	0.984
06329500	6	20190606	1530	20.3	5.25	D-96	1/4	6.029	1.148
06329500	6	20190625	1500	17.3	5.25	D-96	1/4	6.421	1.223
06610000	7	20140422	1000	12.8	3.87	D-96-A1	1/4	2.827	0.730
06610505	8	20161019	1130	15.5	3.80	DH-2	1/4	3.748	0.986
06610505	8	20170221	1230	5.4	3.40	DH-2	1/4	2.727	0.802
06610505	8	20170523	1130	14.3	4.27	DH-2	3/16	4.489	1.051
06610505	8	20170627	1230	21.1	4.00	DH-2	3/16	4.436	1.109
06610505	8	20171017	1200	12.6	4.10	DH-2	3/16	3.783	0.923
06610505	8	20180619	1200	24.7	4.40	DH-2	3/16	3.664	0.833
06610505	8	20181017	1230	9.3	5.75	DH-2	1/4	5.587	0.972
06818000	9	20180313	1040	3.0	5.10	D-96	3/16	5.224	1.024
06818000	9	20180411	1044	5.3	4.00	D-96	3/16	4.402	1.101
06818000	9	20180418	1015	5.0	4.60	D-96	1/4	2.878	0.626
06818000	9	20180503	1130	16.0	4.90	D-96	1/4	2.590	0.529
06818000	9	20180626	1115	26.0	7.00	D-96	1/4	4.504	0.643
06818000	9	20180702	1015	26.0	6.10	D-96	3/16	3.288	0.539
06818000	9	20180710	0945	27.0	5.30	D-96	3/16	3.682	0.695
06818000	9	20180814	1045	27.0	4.50	D-96	3/16	4.383	0.974
06818000	9	20180829	1030	25.0	3.90	D-96	3/16	3.329	0.854
06818000	9	20180905	1030	24.0	5.56	D-96	3/16	5.753	1.035
06818000	9	20180918	1044	25.0	4.10	D-96	3/16	3.477	0.848
06818000	9	20181024	1010	11.0	4.70	D-96	3/16	3.391	0.722
06818000	9	20181107	1030	9.0	6.60	D-96	3/16	7.233	1.096
06818000	9	20190423	1049	14.5	5.60	D-96	3/16	4.184	0.747
06818000	9	20190618	1040	24.1	5.50	D-96	3/16	5.858	1.065
06818000	9	20190702	1140	28.6	5.65	D-96	3/16	3.905	0.691
06818000	9	20190712	1100	27.0	7.00	D-96	3/16	4.845	0.692
06818000	9	20190805	1145	26.2	4.20	D-96	3/16	3.766	0.897
06818000	9	20190827	1000	23.5	4.70	D-96	3/16	4.957	1.055
06818000	9	20190910	1037	23.9	5.10	D-96	3/16	5.012	0.983

Table 1.2. Intake efficiency data for each site and sample (U.S. Geological Survey, 2022).—Continued

[ID, identification; °C, degree Celsius; ft/s, feet per second; in., inch]

Site number	Site ID (fig. 1.1)	Date	Time	Water temperature (°C)	Stream velocity (ft/s)	Sampler type	Nozzle diameter (in.)	Nozzle velocity	Intake efficiency
06818000	9	20200108	1130	3.0	4.13	D-96	3/16	5.415	1.313
06818000	9	20200206	1040	0.7	5.70	D-96	3/16	5.753	1.009
06818000	9	20200311	1130	7.0	7.10	D-96	3/16	7.343	1.034
06818000	9	20200602	1110	21.0	3.80	D-96	3/16	3.945	1.038
06887000	10	20200617	1310	22.7	2.79	DH-2	1/4	3.355	1.202
06890100	11	20200515	1020	17.4	3.98	DH-2	1/4	4.286	1.077
06893000	12	20171214	1120	2.0	4.30	D-96	1/4	5.405	1.257
06893000	12	20180307	1355	4.0	5.00	D-96	1/4	6.543	1.309
06893000	12	20180313	1330	4.5	4.00	D-96	3/16	4.122	1.031
06893000	12	20180411	1400	6.7	4.90	D-96	3/16	4.851	0.990
06893000	12	20180411	1401	6.7	5.30	D-96	3/16	5.685	1.073
06893000	12	20180411	1402	6.7	5.20	D-96	3/16	4.997	0.961
06893000	12	20180411	1403	6.7	2.80	D-96	3/16	3.068	1.096
06893000	12	20180418	1315	7.0	4.20	D-96	3/16	4.603	1.096
06893000	12	20180503	1415	17.0	4.20	D-96	3/16	4.184	0.996
06893000	12	20180515	1320	20.0	3.50	D-96	3/16	3.647	1.042
06893000	12	20180626	1422	26.0	7.00	D-96	3/16	7.364	1.052
06893000	12	20180702	1340	26.0	6.00	D-96	3/16	3.540	0.590
06893000	12	20180702	1410	26.0	6.10	D-96	3/16	3.682	0.604
06893000	12	20180710	1245	28.0	5.10	D-96	3/16	3.682	0.722
06893000	12	20180710	1315	28.5	5.10	D-96	3/16	3.682	0.722
06893000	12	20180814	1440	20.0	4.00	D-96	3/16	4.603	1.151
06893000	12	20180829	1300	25.0	4.40	D-96	3/16	4.822	1.096
06893000	12	20180918	1136	26.0	5.60	D-96	3/16	4.742	0.847
06893000	12	20181016	1423	11.5	5.20	D-96	3/16	5.260	1.012
06893000	12	20181024	1320	12.0	5.60	D-96	3/16	5.439	0.971
06893000	12	20181101	1030	11.9	5.10	D-96	3/16	5.370	1.053
06893000	12	20181107	1330	9.7	6.10	D-96	3/16	7.057	1.157
06893000	12	20190226	1231	0.8	4.36	D-96	1/4	4.317	0.990
06893000	12	20190315	1230	3.3	7.75	D-96	1/4	7.789	1.006
06893000	12	20190423	1424	14.7	5.70	D-96	3/16	4.746	0.833
06893000	12	20190530	1415	19.0	9.00	D-96	3/16	13.808	1.534
06893000	12	20190618	1340	24.3	6.00	D-96	3/16	6.236	1.039
06893000	12	20190625	1300	24.3	7.50	D-96	3/16	8.469	1.129
06893000	12	20190702	1445	28.2	5.65	D-96	3/16	6.416	1.136
06893000	12	20190712	1415	27.0	7.00	D-96	3/16	7.081	1.012
06893000	12	20190730	1340	27.0	5.30	D-96	3/16	6.575	1.241
06893000	12	20190805	1430	26.5	4.70	D-96	3/16	4.484	0.954
06893000	12	20190827	1445	24.5	5.70	D-96	3/16	5.638	0.989
06893000	12	20190910	1337	25.2	6.00	D-96	3/16	6.533	1.089
06893000	12	20191022	1150	12.9	6.60	D-96	3/16	7.233	1.096

Table 1.2. Intake efficiency data for each site and sample (U.S. Geological Survey, 2022).—Continued

[ID, identification; °C, degree Celsius; ft/s, feet per second; in., inch]

Site number	Site ID (fig. 1.1)	Date	Time	Water temperature (°C)	Stream velocity (ft/s)	Sampler type	Nozzle diameter (in.)	Nozzle velocity	Intake efficiency
06893000	12	20200311	1445	8.5	6.40	D-96	3/16	6.415	1.002
06893000	12	20200323	1135	6.4	5.20	D-96	1/4	5.180	0.996
06934500	13	20170927	1128	27.5	3.40	D-96	1/4	2.482	0.730
06934500	13	20170928	0800	15.0	2.50	D-96	3/16	4.091	1.636
06934500	13	20171026	1013	13.9	5.00	D-96	1/4	3.552	0.710
06934500	13	20171121	1236	8.3	2.90	D-96	3/16	2.762	0.952
06934500	13	20180124	1400	1.1	4.00	D-96	1/4	2.536	0.634
06934500	13	20180328	1250	7.2	5.50	D-96	1/4	3.977	0.723
06934500	13	20180419	1210	9.9	4.80	D-96	1/4	3.330	0.694
06934500	13	20180926	1155	23.7	5.00	D-96	1/4	3.862	0.772
06934500	13	20181114	1225	6.0	4.55	D-96	1/4	4.551	1.000
06934500	13	20190820	1002	27.1	5.80	D-96	1/4	4.103	0.707
06934500	13	20190912	0950	25.8	4.60	D-96	1/4	3.060	0.665
06934500	13	20190925	1055	24.4	5.20	D-96	1/4	3.977	0.765
06934500	13	20191022	1100	13.9	5.00	D-96	1/4	4.383	0.877
06934500	13	20200310	1147	7.7	3.54	D-96	1/4	3.544	1.001
07010000	14	20160607	1202	25.2	5.50	D-96	3/16	4.710	0.856
07010000	14	20160705	1315	24.7	3.20	D-96	3/16	2.979	0.931
07010000	14	20160802	1204	29.3	5.00	D-96	3/16	4.762	0.952
07010000	14	20161004	1200	18.9	5.50	D-96	3/16	5.266	0.957
07010000	14	20161031	1328	16.0	5.00	D-96	3/16	4.772	0.954
07010000	14	20161205	1455	6.1	4.20	D-96	3/16	4.067	0.968
07010000	14	20170109	1638	−0.1	3.10	D-96	3/16	3.050	0.984
07010000	14	20170314	1137	5.6	4.00	D-96	3/16	3.971	0.993
07010000	14	20170410	1530	12.3	5.50	D-96	3/16	5.523	1.004
07010000	14	20171012	1144	20.1	4.40	D-96	3/16	4.401	1.000
07010000	14	20171114	1210	8.2	4.00	D-96	3/16	3.751	0.938
07010000	14	20171220	1423	5.3	3.80	D-96	1/4	2.843	0.748
07010000	14	20180129	1645	2.7	3.60	D-96	3/16	3.142	0.873
07010000	14	20180227	1128	3.1	3.80	D-96	3/16	3.443	0.906
07010000	14	20180403	1137	8.0	5.60	D-96	3/16	5.370	0.959
07010000	14	20180501	1314	14.4	4.70	D-96	3/16	4.418	0.940
07010000	14	20180611	1306	27.2	4.60	D-96	3/16	4.603	1.001
07010000	14	20180724	1256	28.4	4.10	D-96	3/16	3.702	0.903
07010000	14	20180801	1510	25.8	4.50	D-96	3/16	4.746	1.055
07010000	14	20180905	1122	26.8	4.70	D-96	3/16	4.278	0.910
07010000	14	20181001	1522	20.0	3.60	D-96	3/16	3.257	0.905
07010000	14	20181106	1414	10.2	4.10	D-96	3/16	3.659	0.893
07010000	14	20181220	1023	3.2	4.60	D-96	3/16	4.050	0.880
07010000	14	20181220	1042	3.2	4.60	D-96	3/16	4.103	0.892
07010000	14	20190213	1355	0.9	4.60	D-96	3/16	4.066	0.884

Table 1.2. Intake efficiency data for each site and sample (U.S. Geological Survey, 2022).—Continued

[ID, identification; °C, degree Celsius; ft/s, feet per second; in., inch]

Site number	Site ID (fig. 1.1)	Date	Time	Water temperature (°C)	Stream velocity (ft/s)	Sampler type	Nozzle diameter (in.)	Nozzle velocity	Intake efficiency
07010000	14	20190326	1136	6.7	4.20	D-96	3/16	3.653	0.870
07010000	14	20190501	1122	15.7	4.00	D-96	3/16	3.440	0.860
07010000	14	20190530	1120	20.7	4.50	D-96	3/16	4.044	0.899
07010000	14	20190617	1402	23.2	5.00	D-96	3/16	4.492	0.898
07010000	14	20190715	1356	28.2	4.40	D-96	3/16	3.945	0.897
07010000	14	20190819	1502	28.1	5.10	D-96	3/16	4.686	0.919
07020500	15	20160503	1536	17.2	5.50	D-96	3/16	5.725	1.041
07020500	15	20160607	1633	24.9	6.10	D-96	3/16	5.464	0.896
07020500	15	20160802	1619	29.6	5.30	D-96	3/16	5.381	1.015
07020500	15	20160907	1531	26.1	5.40	D-96	3/16	5.397	1.000
07020500	15	20161004	1638	19.9	5.90	D-96	3/16	5.382	0.912
07020500	15	20161101	1151	16.1	4.60	D-96	3/16	4.326	0.940
07020500	15	20161206	1111	6.0	4.50	D-96	3/16	4.346	0.966
07020500	15	20170315	1641	6.0	4.70	D-96	3/16	4.559	0.970
07020500	15	20170411	1056	12.3	6.90	D-96	3/16	6.950	1.007
07020500	15	20171003	1117	22.7	2.71	D-96	3/16	2.711	1.000
07020500	15	20171115	1125	7.6	3.50	D-96	3/16	3.291	0.940
07020500	15	20171205	1022	7.8	3.70	D-96	3/16	3.502	0.946
07020500	15	20180404	1032	7.2	6.20	D-96	3/16	5.703	0.920
07020500	15	20180502	0958	15.0	4.70	D-96	3/16	4.681	0.996
07020500	15	20180614	1336	28.5	5.40	D-96	3/16	5.247	0.972
07020500	15	20180716	1451	30.1	5.50	D-96	3/16	5.088	0.925
07020500	15	20180813	1307	28.8	4.10	D-96	3/16	3.978	0.970
07020500	15	20180910	1401	23.7	7.10	D-96	3/16	6.559	0.924
07020500	15	20181022	1454	12.2	8.90	D-96	3/16	7.962	0.895
07020500	15	20181107	1113	10.6	4.50	D-96	3/16	3.864	0.859
07020500	15	20181220	1429	3.2	4.60	D-96	3/16	4.151	0.902
07020500	15	20190219	1328	0.8	4.60	D-96	3/16	4.125	0.897
07020500	15	20190326	1639	7.2	5.40	D-96	3/16	4.818	0.892
07020500	15	20190424	1303	13.9	4.90	D-96	3/16	4.221	0.861
07020500	15	20190618	1324	23.2	5.60	D-96	3/16	5.172	0.924
07020500	15	20190716	1325	27.8	4.60	D-96	3/16	4.152	0.903
07020500	15	20190820	1023	27.9	4.30	D-96	3/16	3.912	0.910
07022000	16	20160504	1048	17.1	5.50	D-96	3/16	5.109	0.929
07022000	16	20160608	1110	24.5	5.10	D-96	3/16	5.013	0.983
07022000	16	20160727	1330	29.8	5.50	D-96	3/16	4.996	0.908
07022000	16	20160822	1545	27.8	5.50	D-96	3/16	5.198	0.945
07022000	16	20160908	1228	26.3	5.00	D-96	3/16	5.094	1.019
07022000	16	20161005	1134	20.0	6.00	D-96	3/16	5.571	0.928
07022000	16	20161101	1655	16.9	4.00	D-96	3/16	3.797	0.949
07022000	16	20161206	1640	6.5	5.00	D-96	3/16	4.633	0.927

Table 1.2. Intake efficiency data for each site and sample (U.S. Geological Survey, 2022).—Continued

[ID, identification; °C, degree Celsius; ft/s, feet per second; in., inch]

Site number	Site ID (fig. 1.1)	Date	Time	Water temperature (°C)	Stream velocity (ft/s)	Sampler type	Nozzle diameter (in.)	Nozzle velocity	Intake efficiency
07022000	16	20170321	1320	7.2	4.00	D-96	3/16	3.677	0.919
07022000	16	20170411	1625	12.4	6.40	D-96	3/16	6.096	0.952
07022000	16	20170913	1507	23.2	5.10	D-96	3/16	4.810	0.943
07022000	16	20171205	1521	8.3	4.40	D-96	3/16	4.170	0.948
07022000	16	20180404	1505	8.3	6.00	D-96	3/16	5.882	0.980
07022000	16	20180418	1348	10.1	5.10	D-96	3/16	4.513	0.885
07022000	16	20180502	1510	15.0	4.60	D-96	3/16	4.218	0.917
07022000	16	20180529	1652	25.1	5.10	D-96	3/16	4.711	0.924
07022000	16	20180612	1040	27.6	4.90	D-96	3/16	4.683	0.956
07022000	16	20180625	1508	27.1	5.50	D-96	3/16	5.300	0.964
07022000	16	20180711	1650	29.4	4.90	D-96	3/16	4.858	0.991
07022000	16	20180723	1638	28.7	4.80	D-96	3/16	4.734	0.986
07022000	16	20180813	1720	28.8	5.10	D-96	3/16	4.603	0.902
07022000	16	20180910	1810	24.5	6.10	D-96	3/16	5.707	0.936
07022000	16	20181023	1115	11.9	4.80	D-96	3/16	4.252	0.886
07022000	16	20181203	1455	4.4	5.00	D-96	3/16	4.452	0.890
07022000	16	20190220	1050	1.1	4.80	D-96	3/16	4.308	0.897
07022000	16	20190311	1415	2.8	4.50	D-96	3/16	3.945	0.877
07022000	16	20190327	1200	7.2	5.20	D-96	3/16	4.729	0.909
07022000	16	20190417	1050	12.2	7.00	D-96	3/16	5.948	0.850
07022000	16	20190429	1635	14.7	4.60	D-96	3/16	4.089	0.889
07022000	16	20190528	1545	20.3	5.50	D-96	3/16	5.392	0.980
07022000	16	20190612	1234	23.8	7.10	D-96	3/16	6.389	0.900
07022000	16	20190624	1612	23.7	6.80	D-96	3/16	6.248	0.919
07022000	16	20190730	1656	28.2	4.20	D-96	3/16	3.965	0.944
07022000	16	20190820	1540	28.8	4.50	D-96	3/16	4.195	0.932
07032000	17	20180417	1300	11.4	7.02	D-96	3/16	5.740	0.818
07032000	17	20180530	1300	25.0	5.92	D-96	3/16	5.226	0.883
07032000	17	20180619	1200	28.9	5.28	D-96	3/16	4.385	0.830
07032000	17	20180718	1300	30.1	4.94	D-96	3/16	4.195	0.849
07032000	17	20180821	1300	28.3	4.14	D-96	1/4	3.654	0.883
07032000	17	20180920	1300	25.5	6.86	D-96	3/16	5.446	0.794
07032000	17	20181023	1300	15.0	6.04	D-96	3/16	5.349	0.886
07032000	17	20181218	1300	6.2	6.20	D-99	3/16	6.517	1.051
07032000	17	20190204	1130	3.6	6.30	D-99	3/16	5.052	0.802
07032000	17	20190204	1150	3.6	7.40	D-99	3/16	6.835	0.924
07032000	17	20190204	1155	3.6	8.20	D-99	3/16	8.188	0.999
07032000	17	20190204	1207	3.6	6.90	D-99	3/16	5.452	0.790
07032000	17	20190204	1211	3.6	4.90	D-99	3/16	4.128	0.842
07032000	17	20190204	1225	3.6	6.60	D-99	3/16	6.671	1.011
07032000	17	20190204	1250	3.6	7.50	D-99	3/16	7.101	0.947

Table 1.2. Intake efficiency data for each site and sample (U.S. Geological Survey, 2022).—Continued

[ID, identification; °C, degree Celsius; ft/s, feet per second; in., inch]

Site number	Site ID (fig. 1.1)	Date	Time	Water temperature (°C)	Stream velocity (ft/s)	Sampler type	Nozzle diameter (in.)	Nozzle velocity	Intake efficiency
07032000	17	20190204	1256	3.6	8.00	D-99	3/16	7.796	0.975
07032000	17	20190204	1302	3.6	6.20	D-99	3/16	5.216	0.841
07032000	17	20190204	1307	3.6	6.00	D-99	3/16	4.296	0.716
07032000	17	20190221	1232	4.6	7.00	D-99	3/16	6.968	0.995
07032000	17	20190221	1243	4.6	8.00	D-99	3/16	7.225	0.903
07032000	17	20190221	1250	4.6	7.60	D-99	3/16	7.866	1.035
07032000	17	20190221	1255	4.6	4.90	D-99	3/16	4.242	0.866
07032000	17	20190221	1303	4.6	4.60	D-99	3/16	4.787	1.041
07032000	17	20190227	1216	7.4	6.80	D-99	3/16	6.361	0.935
07032000	17	20190227	1227	7.4	9.80	D-99	3/16	8.910	0.909
07032000	17	20190227	1233	7.4	8.80	D-99	3/16	8.713	0.990
07032000	17	20190227	1237	7.4	7.70	D-99	3/16	6.519	0.847
07032000	17	20190227	1243	7.4	5.50	D-99	3/16	5.686	1.034
07032000	17	20190227	1300	7.4	7.00	D-99	3/16	8.699	1.243
07032000	17	20190227	1304	7.4	8.60	D-99	3/16	8.725	1.015
07032000	17	20190227	1310	7.4	8.80	D-99	3/16	9.131	1.038
07032000	17	20190227	1315	7.4	7.40	D-99	3/16	6.467	0.874
07032000	17	20190227	1319	7.4	5.30	D-99	3/16	5.343	1.008
07032000	17	20190227	1335	7.4	7.50	D-99	3/16	6.844	0.912
07032000	17	20190227	1340	7.4	9.20	D-99	3/16	9.136	0.993
07032000	17	20190227	1345	7.4	9.10	D-99	3/16	9.771	1.074
07032000	17	20190227	1350	7.4	6.50	D-99	3/16	7.119	1.095
07032000	17	20190227	1355	7.4	5.30	D-99	3/16	6.437	1.214
07032000	17	20190326	1330	9.9	6.10	D-99	3/16	4.963	0.814
07032000	17	20190423	1219	15.2	7.50	D-99	3/16	7.173	0.956
07032000	17	20190423	1226	15.2	7.40	D-99	3/16	6.505	0.879
07032000	17	20190423	1234	15.2	7.10	D-99	3/16	6.639	0.935
07032000	17	20190423	1240	15.2	7.00	D-99	3/16	7.218	1.031
07032000	17	20190423	1316	15.2	5.30	D-99	3/16	5.912	1.116
07032000	17	20190618	1252	24.2	7.70	D-99	3/16	7.753	1.007
07032000	17	20190618	1301	24.2	7.00	D-99	3/16	6.292	0.899
07032000	17	20190618	1307	24.2	6.50	D-99	3/16	6.137	0.944
07032000	17	20190618	1313	24.2	6.50	D-99	3/16	5.650	0.869
07032000	17	20190618	1322	24.2	3.90	D-99	3/16	4.118	1.056
07032000	17	20190827	1215	27.8	4.70	D-99	1/4	4.096	0.871
07032000	17	20190827	1220	27.8	4.40	D-99	1/4	3.537	0.804
07032000	17	20190827	1230	27.8	4.10	D-99	1/4	3.415	0.833
07032000	17	20190827	1235	27.8	4.00	D-99	1/4	3.755	0.939
07032000	17	20190827	1245	27.8	2.90	D-99	1/4	2.171	0.749
07032000	17	20191218	1400	6.1	5.60	D-99	1/4	4.185	0.747
07032000	17	20200310	1315	9.3	6.10	D-99	3/16”	5.101	0.836

Table 1.2. Intake efficiency data for each site and sample (U.S. Geological Survey, 2022).—Continued

[ID, identification; °C, degree Celsius; ft/s, feet per second; in., inch]

Site number	Site ID (fig. 1.1)	Date	Time	Water temperature (°C)	Stream velocity (ft/s)	Sampler type	Nozzle diameter (in.)	Nozzle velocity	Intake efficiency
07182250	18	20200514	1100	12.6	3.39	D-96-A1	1/4	4.509	1.330
07182390	19	20200225	1240	6.5	4.28	D-96-A1	1/4	4.722	1.103
07182390	19	20200310	1150	9.5	3.77	D-96-A1	5/16	4.435	1.176
07182390	19	20200514	1310	15.4	3.11	D-96-A1	5/16	4.201	1.351
07373420	20	20130715	1000	27.4	4.80	D-99	1/4	4.966	1.035
07374525	21	20130716	1100	27.7	3.20	D-99	3/16	2.428	0.759
07381495	22	20130718	1000	27.9	5.20	D-99	1/4	4.679	0.900
07381590	23	20130717	0900	27.4	2.97	D-99	1/4	3.132	1.055
07381600	24	20130717	1100	27.3	2.67	D-99	5/16	2.229	0.835
09380000	25	20131111	1650	11.0	3.57	D-96-A1	1/4	2.563	0.718
09380000	25	20140108	1400	8.3	2.92	D-96	1/4	2.316	0.793
09380000	25	20151207	1430	12.4	2.70	D-96-A1	5/16	2.264	0.838
09380000	25	20181106	1100	11.1	6.10	D-96-A1	5/16	3.078	0.505
09404200	26	20150126	1400	9.8	4.40	DH-2	3/16	2.209	0.502
12113390	27	20160830	1238	17.5	1.11	D-96	5/16	0.714	0.643
12113390	27	20161220	1245	5.3	2.00	D-96-A1	5/16	1.243	0.622
12113390	27	20170209	1105	4.8	2.86	D-96-A1	5/16	2.615	0.914
12113390	27	20170210	1030	4.9	3.82	D-96-A1	5/16	2.867	0.751
12170300	28	20150206	1755	8.3	6.40	D-96	1/4	5.180	0.809
410333095530101	29	20160523	1330	17.6	4.90	DH-2	3/16	4.655	0.950
410333095530101	29	20160621	1400	26.2	3.40	DH-2	3/16	2.854	0.839
410333095530101	29	20161019	1230	15.9	4.80	DH-2	1/4	4.366	0.910
410333095530101	29	20161115	1430	10.5	4.50	DH-2	3/16	4.345	0.966
410333095530101	29	20170323	1230	7.4	4.20	DH-2	3/16	3.573	0.851
410333095530101	29	20170413	1230	11.1	4.40	DH-2	3/16	4.621	1.050
410333095530101	29	20170523	1300	14.4	5.20	DH-2	3/16	5.026	0.967
410333095530101	29	20170614	1300	25.1	4.90	DH-2	3/16	4.787	0.977
410333095530101	29	20170828	1230	23.3	5.00	DH-2	3/16	4.603	0.921
410333095530101	29	20171017	1300	13.1	5.00	DH-2	3/16	4.464	0.893
410333095530101	29	20180319	1300	2.9	4.50	DH-2	3/16	3.931	0.874
410333095530101	29	20180522	1400	16.3	6.00	DH-2	3/16	5.139	0.856
410333095530101	29	20180726	1330	26.4	6.00	DH-2	3/16	6.853	1.142
410333095530101	29	20181017	1330	9.4	6.75	DH-2	3/16	6.536	0.968
410333095530101	29	20190723	1300	26.0	7.40	DH-2	3/16	7.536	1.018
411636095535401	30	20160523	1100	17.6	4.50	DH-2	1/4	5.256	1.168
411636095535401	30	20160621	1130	25.8	4.50	DH-2	1/4	4.150	0.922
411636095535401	30	20160712	1130	26.7	4.10	DH-2	3/16	3.949	0.963
411636095535401	30	20160728	1000	28.6	4.00	DH-2	1/4	4.275	1.069
411636095535401	30	20161019	1030	15.3	3.80	DH-2	1/4	4.123	1.085
411636095535401	30	20170124	1100	1.3	4.00	DH-2	1/4	3.678	0.919
411636095535401	30	20170221	1100	5.0	3.40	DH-2	1/4	3.617	1.064

Table 1.2. Intake efficiency data for each site and sample (U.S. Geological Survey, 2022).—Continued

[ID, identification; °C, degree Celsius; ft/s, feet per second; in., inch]

Site number	Site ID (fig. 1.1)	Date	Time	Water temperature (°C)	Stream velocity (ft/s)	Sampler type	Nozzle diameter (in.)	Nozzle velocity	Intake efficiency
411636095535401	30	20170523	1030	14.2	4.40	DH-2	1/4	4.683	1.064
411636095535401	30	20170816	1030	23.8	4.23	DH-2	3/16	3.562	0.842
411636095535401	30	20170828	1030	23.1	4.10	DH-2	3/16	3.954	0.964
411636095535401	30	20171017	1030	12.5	4.60	DH-2	3/16	3.752	0.816
411636095535401	30	20171218	1030	1.9	3.60	DH-2	1/4	3.078	0.855
411636095535401	30	20180620	1030	24.1	4.93	DH-2	3/16	4.750	0.963
411636095535401	30	20181017	1100	9.2	6.20	DH-2	3/16	4.357	0.703
411636095535401	30	20190417	1030	7.8	5.70	DH-2	3/16	5.470	0.960
411636095535401	30	20190619	1030	20.9	5.20	DH-2	3/16	4.050	0.779
411636095535401	30	20190821	1030	25.8	5.30	DH-2	3/16	5.290	0.998
411636095535401	30	20190826	1110	23.2	5.10	DH-2	3/16	4.541	0.890
411636095535401	30	20190926	1030	21.5	6.53	D-96-A1	3/16	6.551	1.003
411636095535401	30	20200318	1030	4.5	4.40	D-96-A1	3/16	4.773	1.085
411636095535401	30	20200610	1010	23.5	4.70	D-96-A1	3/16	4.034	0.858
412126095565201	31	20151117	0900	10.0	4.60	DH-2	1/4	5.833	1.268
412126095565201	31	20160315	0930	11.0	4.30	DH-2	1/4	4.644	1.080
412126095565201	31	20160523	0930	17.5	4.70	DH-2	1/4	5.265	1.120
412126095565201	31	20160621	0930	25.7	4.40	DH-2	1/4	5.335	1.213
412126095565201	31	20160728	0900	28.4	3.90	DH-2	3/16	3.822	0.980
412126095565201	31	20160829	0900	23.9	4.70	DH-2	1/4	5.128	1.091
412126095565201	31	20161019	0900	15.2	4.30	DH-2	1/4	3.705	0.862
412126095565201	31	20161115	0930	9.7	4.70	DH-2	1/4	4.253	0.905
412126095565201	31	20170124	0930	1.3	4.30	DH-2	1/4	3.977	0.925
412126095565201	31	20170323	0900	6.3	4.00	DH-2	1/4	4.436	1.109
412126095565201	31	20170413	0900	9.9	4.50	DH-2	1/4	4.777	1.062
412126095565201	31	20170523	0900	14.2	5.30	DH-2	3/16	5.155	0.973
412126095565201	31	20170627	0930	20.7	4.90	DH-2	3/16	8.174	1.668
412126095565201	31	20170727	0900	26.5	4.00	DH-2	1/4	4.429	1.107
412126095565201	31	20170816	0900	23.9	4.37	DH-2	1/4	4.635	1.061
412126095565201	31	20170828	0930	23.2	4.50	DH-2	1/4	4.651	1.034
412126095565201	31	20171017	0930	12.5	4.50	DH-2	3/16	4.436	0.986
412126095565201	31	20171218	0930	1.9	4.00	DH-2	3/16	5.387	1.347
412126095565201	31	20180319	0900	2.1	4.00	DH-2	3/16	4.629	1.157
412126095565201	31	20180418	1000	5.2	5.70	DH-2	3/16	5.144	0.902
412126095565201	31	20180619	0900	24.5	5.40	DH-2	3/16	5.162	0.956
412126095565201	31	20180920	0900	23.9	5.20	DH-2	3/16	5.627	1.082
412126095565201	31	20190417	0900	7.8	6.80	DH-2	3/16	5.804	0.853
412126095565201	31	20191212	0930	0.6	5.00	D-96-A1	3/16	5.448	1.090
412126095565201	31	20200318	1000	4.5	6.00	D-96-A1	3/16	5.837	0.973
412126095565201	31	20200526	0850	18.2	4.90	D-96-A1	3/16	4.503	0.919
412126095565201	31	20200610	0920	23.5	5.10	D-96-A1	3/16	5.403	1.059

Table 1.3. Summary of stream velocity data categorized by bag sampler type and nozzle diameter.

[ft/s, feet per second; in., inch]

Stream velocity (ft/s)	Bag sampler				Nozzle diameter		
	US D-96	US D-96-A1	US D-99	US DH-2	3/16 in.	1/4 in.	5/16 in.
Number of measurements	217	18	54	80	262	90	17
Average	4.74	4.23	6.34	4.40	5.24	4.19	2.89
Minimum	1.11	2.00	2.67	1.97	1.29	1.97	1.11
Maximum	9.00	6.53	9.80	7.40	9.80	7.75	6.10
25th percentile	4.00	3.44	5.23	4.00	4.28	3.58	2.30
Median	4.70	4.08	6.50	4.39	5.10	4.08	2.86
75th percentile	5.50	4.98	7.50	4.90	6.00	4.70	3.11
Standard deviation	1.26	1.24	1.71	0.99	1.38	0.98	1.07

Table 1.4. Summary of water temperature data categorized by bag sampler type and nozzle diameter.

[°C, degrees Celsius; in., inch]

Water temperature (°C)	Bag sampler				Nozzle diameter		
	US D-96	US D-96-A1	US D-99	US DH-2	3/16 in.	1/4 in.	5/16 in.
Number of measurements	217	18	54	80	262	90	17
Average	17.5	11.2	12.5	16.3	16.2	16.7	13.7
Minimum	−0.1	0. 6	3.6	1.3	−0.1	0.8	2.2
Maximum	30.1	23.5	27.9	28.6	30.1	29.9	27.3
25th percentile	8.3	5.0	4.6	9.9	7.4	9.4	5.5
Median	18.9	11.1	7.4	16.1	15.2	16.3	12.4
75th percentile	26.0	14.7	24.2	23.8	24.8	25.8	17.5
Standard deviation	9.1	7.0	9.3	8.1	9. 1	9.0	8.6

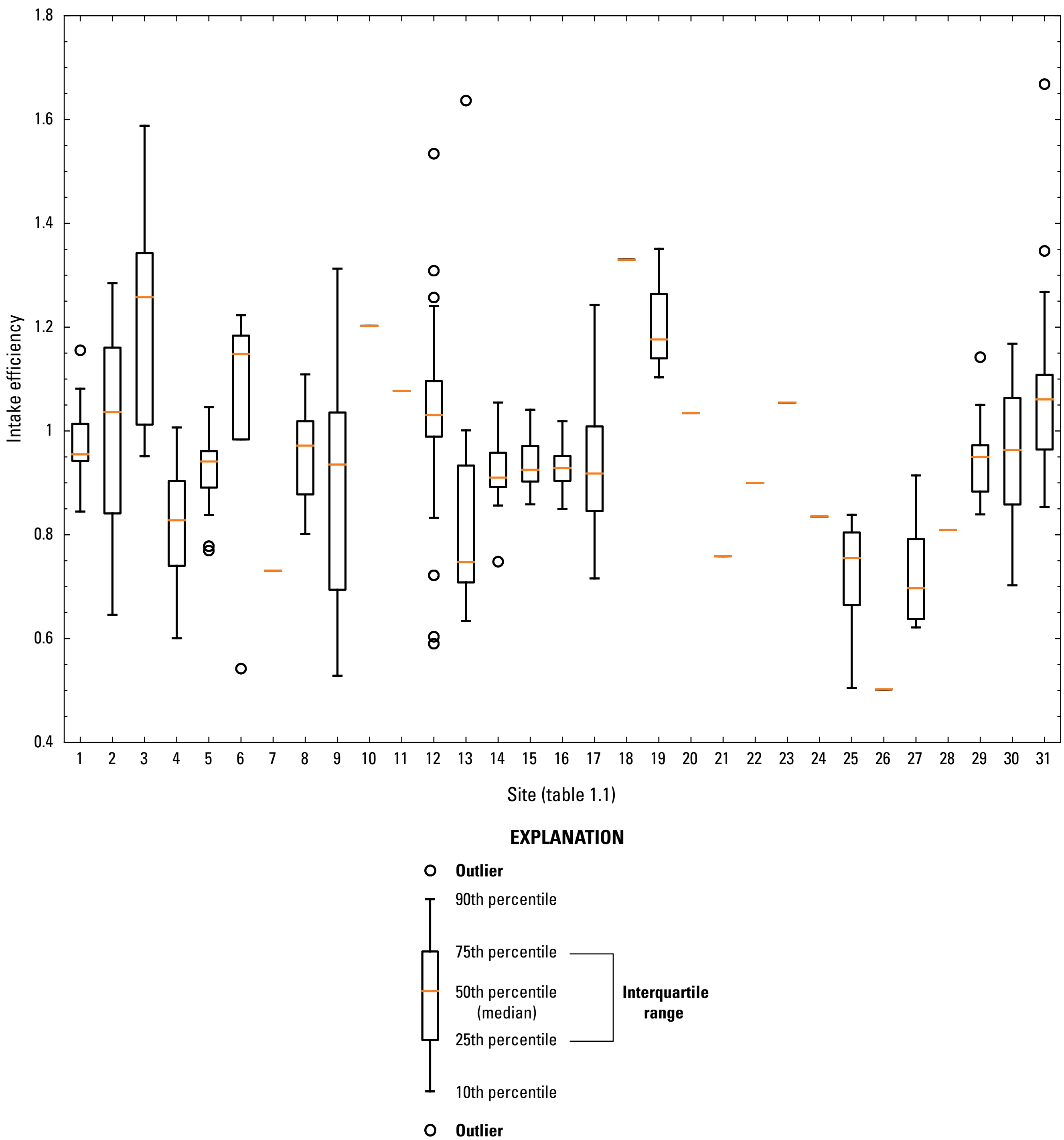

Figure 1.1. Intake efficiency values for each site.

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