1. **Submittal Information**

|  |  |
| --- | --- |
| **Project Name:** |       |
|  | **[ ]  DEC Municipal Grants and Loan Funded Project** |
| **Project Description:** |       |

1. **Facility Information**

|  |  |  |  |
| --- | --- | --- | --- |
| **Facility Name:** |       | **Phone:** |       |
| **AKA:** |       | **Fax:** |       |
| **Physical Address:** |       |
| **Drinking Water System ID (PWSID):** |       |
| **Legal Description:** | Lot: |       | Block: |       | Subdivision: |       | Addition: |       |
| **or** |  |  |  |  |  |  |  |  |  |  |
| **Location:** | Meridian: |       | Section: |       | Township: |       | Range: |       | Tax Lot: |       |

1. **System Owner**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **First Name:** |       | **Last Name:** |       | **Phone:** |       |
| **Company Name:** |       | **Fax:** |       |
| **Mailing Address:** |       |  |  |
| **City:** |       | **State:** |       | **Zip Code:** |       |
| **Email Address:** |       |

1. **Owner's Statement**

|  |
| --- |
| I have authorized submittal of the enclosed items for the above referenced project. I acknowledge the public water system’s responsibility at all times for the quality of the water served by it. By my signature, I certify the information above is correct and my authority to sign this statement (18 AAC 15.030) as the owner of the public water system and applicant for approval of the above listed project is based on one of the following: |
| [ ]  | **Corporation:** I am a principal executive officer of at least the level of vice president or his/her duly authorized representative, if the representative is responsible for the overall management of the project or operation. |
| [ ]  | **Partnership:** I am a general partner. |
| [ ]  | **Sole proprietorship:** I am the proprietor. |
| [ ]  | **Municipal, State, Federal or other public facility:** I am either a principal executive officer, ranking elected official, or other duly authorized employee. |
|  |  |       |
| **Owner’s Signature** |  | **Date** |

This form must be attached to a completed and signed General Information Form.

1. **Lead Person Conducting Tracer Test:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **First Name:** |       | **Last Name:** |       | **Phone:** |       |
| **Title:** |       | **License:**  |       |
| **Company Name:** |       | **Fax:** |       |
| **Mailing Address:** |       |  |  |
| **City:** |       | **State:** |       | **Zip Code:** |       |
| **Email Address:** |       |

1. **Lead System Operator During Test:**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **First Name:** |       | **Last Name:** |       | **Phone:** |       |
| **Title:** |       | **License:**  |       |
| **Company Name:** |       | **Fax:** |       |
| **Mailing Address:** |       |  |  |
| **City:** |       | **State:** |       | **Zip Code:** |       |
| **Email Address:** |       |

1. **Roles and Responsibilities:**

|  |
| --- |
| Describe the roles and responsibilities of those that will be present during the tracer study test.       |
| **Tracer Study Overview:** Please provide a brief overview of the tracer study proposed including the dates/times of test, and drinking water system operation during test (offline/ fully operational and operating within design parameters).       |

1. **System Information:**

|  |  |
| --- | --- |
|  |  **[ ]  System Schematic Attached**  |

Please attach a system schematic showing the unit processes (identify any being tested), the point of tracer addition, sampling location(s), flow meters (used in the tracer study), and any other locations referenced in this submittal or pertinent to the test.

|  |  |
| --- | --- |
|  |  **[ ]  Reactor Cross Section Attached**  |

Please attach a cross sectional diagram showing the baffling structures and dimensions of the reactor(s) evaluated.

* 1. **System Flows and Reservoir Levels**

Summarize system flows and reservoir levels and describe how they were estimated (please attach any supporting calculations or historical flow data).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Season | Average Treatment Flow in Plant (gpm) | Average Clearwell Level (ft) | Peak Hourly Demand (gpm) | Average Flow into Distribution (gpm) |
|       |       |       |       |       |
|       |       |       |       |       |
|       |       |       |       |       |
|       |       |       |       |       |

* 1. **Unit Processes**

List all treatment unit processes (including pre-chlorination, flocculation, sedimentation, filter pumps, pressure filtration, GAC, post chlorination, clearwell contact time).

* 1. **Process(s) Evaluated in the Tracer Test**

Describe in detail the reactor(s) that will be evaluated during the tracer test including the following items.

* + 1. **Reactor Type(s)**

Describe the function of the reactor(s) to be tested.

* + 1. **Reactor Dimensions**

Describe the dimensions and configuration of the reactors to be tested. If there are two or more reactors indicate if the reactors are operated in series or parallel.

* + 1. **Inlet / Outlet Configuration**

Describe the inlet and outlet configuration through the tested reactor(s).

* + 1. **Number of Baffles and L:W or L:D Ratio and Projected t10/T**

Indicate the number of baffles in the reactor(s) tested and the L:W or L:D ratio. For basins, the length is the longest path that the water can travel. The width is the average width of the travel channel. For pipelines, please indicate the length to inner diameter ratio.

* + 1. **Other (as applicable)**

* 1. **Exit Flow (pump or gravity), Flow Control and Flow Metering**

Describe the exit flow, how it is controlled, and the flow metering of the flow.

* 1. **Water Discharges Associated with Tracer Study**

Describe the water discharge associated with the tracer study. Items should include the rate of discharge, the total volume of discharge; the best management practices used to address erosion or icing issues; and the location and description of the discharge point.

* 1. **Other**

Provide any other information that is pertinent to the tracer test.

1. **Tracer Test Method and Dosing**
	1. **Test Method**

 **[ ]  Step-Dose**

 **[ ]  Modified Step-Dose**

 **[ ]  Cumulative Volume**

 **[ ]  Other (alternate test method must be approved by DEC prior to conducting test)**

Briefly discuss why the selected test method was chosen.

* 1. **Tracer Type**

Select which tracer will be used and enter its commercial purity and specific gravity.

|  |
| --- |
| **Dry Anhydrous Tracer Material** |
|  | TracerIon | TracerMaterial | MW, g/mol | Ion MW, g/mol | Ion MW, g/mol | \*Solubilityg/L | 1 Purity% |
|[ ]  Na | NaCl | 58.44 | 22.99 as Na+ | 35.45 as Cl- | 357 |  |
|[ ]  Cl | NaCl | 58.44 | 22.99 as Na+ | 35.45 as Cl- | 357 |  |
|[ ]  Ca | CaCl2 | 110.98 | 40.08 as Ca+ | 35.45 as Cl- | 595 |  |
|[ ]  Cl | CaCl2 | 110.98 | 40.08 as Ca+ | 35.45 as Cl- | 595 |  |
|[ ]  Li | LiCl | 42.39 | 6.94 as Li+ | 35.45 as Cl- | 692 |  |
|[ ]  F | NaF | 41.99 | 22.99 as Na+ | 18.00 as F- | 36.6 |  |

|  |
| --- |
| **Dry Hydrated Tracer Material** |
|  | TracerIon | TracerMaterial | MW, g/mol | Ion MW, g/mol | Ion MW, g/mol | \* CaCl2Solubility g/L | CaCl2% |
|[ ]  Cl | CaCl2\*H2O | 129 | 40.08 as Ca+ | 35.45 as Cl- | 357 | 86.03 |
|[ ]  Cl | CaCl2\*2H2O | 147 | 22.99 as Na+ | 35.45 as Cl- | 357 | 75.49 |
|[ ]  Cl | CaCl2\*4H2O | 183 | 22.99 as Na+ | 35.45 as Cl- | 357 | 60.63 |
|[ ]  Cl | CaCl2\*6H2O | 219 | 22.99 as Na+ | 35.45 as Cl- | 357 | 50.66 |

\*Solubility at 0 °C

|  |
| --- |
| **Liquid Tracer Material** |
|  | Tracer | Material | MW, g/mol | Ion MW, g/mol | Ion MW, g/mol | 2 SG | 1 Purity% |
|[ ]  Ca | CaCl2 | 110.98 | 40.08 as Ca+ | 35.45 as Cl- |  |  |
|[ ]  Cl | CaCl2 | 110.98 | 40.08 as Ca+ | 35.45 as Cl- |  |  |
|[ ]  F | H2SiF6 | 144.09 | - | 18.00 as F- |  |  |

1. The % purity of the tracer material stated on the Certificate of Analysis.
2. The specific gravity of the purchase liquid material stated on the Certificate of Analysis.
	1. **Indicate the background level of the chosen tracer and the basis for the background determination**

* 1. **Tracer Dosage Summary**

Summarize the flow rates and projected tracer dosages that will be used during continuous tracer feed tests.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Date | Test # | Tested Flow (gpm) | Tank Level (ft) | Tank Residence Time (hours) | Pipeline Residence Time (min) | Tracer Run Time\* (hours) | Tracer DosageIon, (mg/l) |
|       |       |       |       |       |       |       |       |
|       |       |       |       |       |       |       |       |
|       |       |       |       |       |       |       |       |
|       |       |       |       |       |       |       |       |

 \*tracer run time is based on the tank residence time since it is the longest.

* 1. **Chemical Feed Pump – Continuous Tracer Feed**

Identify the chemical feed pump used, the pump capacity, and the calibration cylinder volume used to verify the dosage rate.

* 1. **Tracer Injection**

Please describe the tracer injection points and any pipe bends or mixing before the reactor (the tracer injection point should be noted on the attached schematic).

1. **Tracer Analysis**

Provide the following information for each test.

* 1. **Tracer Sampling Location(s)**

Please describe the tracer sampling locations (the tracer injection point should be noted on the attached schematic) and methods. Discuss how the samples will be taken, whether the sample line will flow continuously, and the approximate flow (mL/min) and the residence detention time of the sample line.

* 1. **Tracer Sample Frequency**

|  |
| --- |
| **Test 1:**       |
| TimeSegment | Sample Time Range(minutes to minutes) | Sample Frequencyminutes | Number of Samples |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|  |  | Total |       |

|  |
| --- |
| **Test 1:**       |
| TimeSegment | Sample Time Range(minutes to minutes) | Sample Frequencyminutes | Number of Samples |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|  |  | Total |       |

|  |
| --- |
| **Test 2:**       |
| TimeSegment | Sample Time Range(minutes to minutes) | Sample Frequencyminutes | Number of Samples |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|  |  | Total |       |

|  |
| --- |
| **Test 2:**       |
| TimeSegment | Sample Time Range(minutes to minutes) | Sample Frequencyminutes | Number of Samples |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|  |  | Total |       |

|  |
| --- |
| **Test 3:**       |
| TimeSegment | Sample Time Range(minutes to minutes) | Sample Frequencyminutes | Number of Samples |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|  |  | Total |       |

|  |
| --- |
| **Test 3:**       |
| TimeSegment | Sample Time Range(minutes to minutes) | Sample Frequencyminutes | Number of Samples |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|       |       |       |       |
|  |  | Total |       |

* 1. **Tracer Sample Analysis**

If the tracer analysis will be conducted on-site then describe the analytic equipment used including the make/model, the last calibration date, the reagents used, the reagent expiration dates, and the sensitivity range.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Analytic Equipment | Make/Model | Last Calibrated | Sensitivity Range | Reagents Used(expiration) |
|       |       |       |       |       |
|       |       |       |       |       |
|       |       |       |       |       |

If the tracer analysis will be conducted by a laboratory, provide the name and location of the laboratory and the method of analysis.

1. **Tracer Results:**

Following completion of the tracer study, a baffle factor will be awarded based upon the submitted results. The tracer study result submittal should include the following information:

* Please discuss any discrepancies from the proposed tracer study plan that was submitted and reviewed by DEC. Please address any project specific issues that were requested in the DEC review.
* The instrumentation used in the tracer study test is critical in the evaluation of the tracer study data. The instruments of interest include the chemical test equipment as well as flow meters. Please provide the following information on tracer study data and instrumentation:
	+ Equipment summary and calibration information for equipment used in the tracer study test.
	+ Attach the calibration check field notes (a check on the validity of the current calibration, not a recalibration).
* Please provide a copy of field data sheets. Each data sheet should include the following:
	+ The name of the reactor tested, the name of the recorder, and the date;
	+ The instrument(s) from which the data was obtained (flow meter, analytical equipment);
	+ The temperature of the water before tracer injection and at each tracer sampling point. If the water temperature varies by more than XX degrees, then the temperature should be monitored throughout the test.
	+ The background concentration of the tracer should be monitored in the water before tracer injection periodically throughout the test.
* If an electronic spreadsheet is used, please provide a copy of the “live” (unlocked and enabled) spreadsheet. The spreadsheet should include a summary tab that lists the equations used in the spreadsheet.
* Please provide photos of the tracer test including reactor being tested, equipment set-up, tracer injection location, and sampling location(s).

Tracer studies are used to determine the efficiency of a disinfection reactor ([Code of Federal Regulations 40 CFR Part 141](http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40cfr141_main_02.tpl) definition of “Disinfectant Contact Time”). Tracer studies are simple in concept; a tracer is added prior to the inlet of a structure and the concentration is measured at the outlet. However, conducting a tracer study can be very challenging. To maximize the potential for success of a tracer study, you must submit a tracer study plan to the department before conducting a tracer study**.** The following information is provided to help prepare and submit a tracer study plan. Sample information is included in grey, to provide additional guidance on the type of information expected.

**General Information**

A “General Information Form” should be included in all submittals to the Department of Environmental Conservation Drinking Water Program engineering section. This form will identify the project (in this case the project is a tracer study), the facility (the public water system tested), and the system owner.

**Tracer Study Proposal**

This section provides contact information for the people involved with the test including their roles and responsibilities, and describes the basic aspects of the tracer study.

**System Information**

The section on system information provides the system configuration details needed to assess the tracer study proposal. A current, labeled schematic must be attached to the submittal. In order to prepare a tracer study plan, an estimate of the expected flows and baffle factor will be necessary.

**Flow Rates and Reservoir Levels:** A minimum of three flow ranges must be tested, with four flow ranges recommended ([Tracer Studies in Water Treatment Facilities: A Protocol and Case Studies](http://www.waterrf.org/Pages/Projects.aspx?PID=166)). In specific circumstances, such as with a system that will only ever experience a single flow rate or a system that has been modeled using computational fluid dynamics, testing of fewer flow ranges may be approved. One of the tested flow regimes should include typical flow rates and tank conditions for peak hourly flow. The other chosen flow ranges should bracket the expected flow regimes for the system. The basic premise is that the baffling efficiency (T10/T) should be fairly constant over the range of flows tested. Studies have shown that the baffling efficiency is slightly lower at lower flow rates. However, a significant variation in baffling efficiency may reveal issues with the ways that the tracer study was conducted or even issues with the facility itself, such as construction anomalies. The highest flow rate tested should be at least 91 percent of the highest flow rate expected through the portion of the facility evaluated. Computational fluid dynamic (CFD) modeling can be used to minimize the number of flow conditions tested. At least one tracer study should be conducted to field validate the CFD modeling results.

EPA guidance ([Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources](http://water.epa.gov/lawsregs/rulesregs/sdwa/swtr/upload/guidsws.pdf), Appendix C: Determination of Disinfectant Contact Time) recommends conducting tests at the minimum normal operating level in storage reservoirs or clearwells. Additionally, it is recommended that the tank level be kept constant during the test. However, some studies suggest that a constant tank level may not represent a worst case condition with respect to hydraulic efficiency and the determination of baffle factor. Therefore, it is recommended that one tested flow regime represent actual expected flow conditions during peak flow. If during peak flow demand conditions the inlet and outlet flows are not equal, then the changing level of the reservoir should be noted.

**Baffle Factor Estimate:** A rough estimate of the expected baffle factor may be obtained by determining the Length: Width or Length: Diameter ratio of the reactor vessel. The following diagrams show how to determine an L:W ratio for rectangular and circular reactor with interior baffles. After determining the L:W ratio and the estimated velocity, the attached graph may also be used to estimate the corresponding baffle factor. This graph is based on multiple data sets including data from the California Department of Public Health.

The provided diagrams and graphs are intended to be used in planning a tracer study for a baffled tank. However, the actual baffle factor may not match, depending on system specific hydraulics, the construction details of the baffles, the age of the baffles, and the flow rates tested.

An L:D ratio for a pipeline can be calculated using the inner pipe diameter and the total flow length of the pipe.

**Exit Flow, Flow Control, and Flow Metering**: After estimating the baffle factor and evaluating the flows that will be tested during the tracer study, it is important to determine how the flow and tank levels will be controlled during the tracer test. An accurate measure of flow rate is critical to obtaining accurate tracer study results. The flow meters used in the test must be calibrated within the manufacturer’s recommendations, and flows must be field validated at the beginning and end of the test.

The impact of the tracer study must also be evaluated against the normal operational demands of the system (can the system provide both water for the test AND the water needed for normal system operations?). The timing of the tracer study must accommodate needed system processes (including filter backwash).

**Figure 1: Determining Length to Width (L:W) Ratio for Rectangular and Circular Reactors**

**Inlet**

**Outlet**

Inlet

Outlet

Length is longest flow path (red line).

Width is the average channel width for each flow path.

**Figure 2: Length-to-Width Ratios vs t10/T – for Baffled Tanks**



**Figure 3: Baffling Factor for Different Flows and L:W Ratios**

 

**Water Discharges Associated with Tracer Study:**

The discharge water associated with the test must be considered. Any discharges must be managed to avoid disrupting or overloading the existing wastewater system, and to avoid erosion/icing issues.

**Discharges to a** wastewater **system (treatment as well as collection) must be evaluated to determine whether the increased loading from the test will adversely affect the system.**

**Discharges to the** surface **that meet the following conditions will not be required to apply for a discharge permit:**

* + - 1. The discharged water is potable drinking water and originates only from the tracer study test;
			2. Is discharged at a rate less than or equal to 50 gallons per minute and less than 30,000 gallons total; and
			3. Is located on the property of the system being tested, is at least 100 feet from the nearest surface water body, and is at least 200 feet from any drinking water system intake.

**Discharges that do not meet all of the above conditions should contact:**

Environmental Program Manager

Discharge Authorization Program – Division of Water

555 Cordova St

Anchorage, AK 99501

907-269-7580

**Tracer Test Method and Dosing**

The choice of the optimum tracer test method, tracer type and the specific dosing requirements for the tracer test are dependent on the specific system characteristics.

**Test Method:** The two main type of tracer studies are step dose tests and slug dose tests. Slug dose tests can result in density current effects because very concentrated solutions are needed to conduct the study. This can be further exaggerated by temperature differences in the water used in the study. We generally recommend using a step dose approach because of this issue and other disadvantages of the slug dose approach.

Two variations of the step dose method that were developed by Guy Schott, may also be performed: the modified-step dose method and the V10 method. The modified step dose method can use significantly less water (approximately one HRT), but requires careful chemical and flow control, and is based on identifying when the effluent concentration is at 25% of the influent dosage concentration. The approximate equation for determining dosage for the desired peak concentration is:



*where BF is the estimated baffle factor*

The V10 method is based on a correlation between flow rate (time) and volume. This method is suitable in situations where there are non-steady-state flows. Non-steady-state flows include flow interruptions due to backwash, periods where the plant is not operating, or instances where the inlet and outlet flows are significantly different. Specifically, V10 is the recorded total volume of water that has exited the reactor from start to t10 when 10% of the tracer mass has exited the reactor.

Where:

  

The V10 method also requires careful calculation and precise control of the chemical dose and flow rates. It is also important to provide details on plan operation during the tracer test (including plant flow, booster pump flow, total production, tracer concentration, tank levels).

**Tracer Type:** Various tracers can be used, though there is no one ideal tracer. The most commonly used and reviewed ones are fluoride, lithium, sodium, chloride, and calcium. The reactor chosen should be stable with a replicable analytic technique.

**Tracer Dosage:** The amount of tracer needed is also be an important consideration. The dosing and amount of chemical needed should be estimated prior to the tracer test. It is recommended that a tracer dose at least 20 mg/L above background level be used during the test. The following equations are provided to assist in calculating the tracer study dosages.

**Tracer Study Dosage Calculation Equations**

**Equation 1: Dosage Calculation**



**Equation 2: Specific Gravity (SG)**

****

**Equation 3: Calculate new Specific Gravity after Dilution**



**Equation 4: Calculate new % Solution Strength after Dilution**



**Equation 5: Chemical feed rate (mL/min) based on target ion dosage and desired % tracer solubility.**



**Tracer Analysis**

**Tracer Sampling Locations**

Lag times associated with the sample locations should be addressed in the sampling plan.

**Tracer Sampling Frequency**

It is important to sample for the tracer often enough, especially shortly after the start of the test, so that the baffling efficiency (T10/T) can be clearly identified. T10 is the time it takes for 10 percent of the tracer to break through and T is the mean hydraulic residence time.

**Suggested Sample Frequency**

|  |  |  |
| --- | --- | --- |
| **Segments** | **Sample****Frequency** | **Time Range** |
| Segment 1 | Ƭ x (0.03-0.05)\* | 0 to (0.5303BF2 + 0.307BF+0.014) x Ƭ |
| Segment 2Critical Region (t10) | Ƭ x (0.01-0.02)\* | (0.5303BF2 + 0.307BF+0.014) x Ƭ to(-0.683BF2 + 1.617BF + 0.0625) x Ƭ |
| Segment 3 | Ƭ x (0.03-0.05)\* | (-0.683BF2 + 1.617BF + 0.0625 to 1.1) x Ƭ |
| Segment 4 | Ƭ x (0.05-0.1)\* | 1.1Ƭ to 3Ƭ |

**BF** (0-1) is the estimated baffling factor that would be achieved if a tracer study were conducted.

**\***Baffling factor increment constants (# to #)

Ƭ = Residence Time of Reactor(s) (minutes)

**Example of Suggested Sample Frequency**

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Samples should also be collected shortly after the point of tracer injection at a frequency of 0.10T to confirm constant tracer addition and accurately estimate tracer recovery. In addition, flow and clearwell level measurements should be collected continuously.

**Tracer Results**

Following completion of the tracer study, a baffle factor will be awarded based upon the submitted results. The tracer study result submittal should include the following information:

* Please discuss any discrepancies from the proposed tracer study plan that was submitted and reviewed by DEC. Please address any project specific issues that were requested in the DEC review.
* The instrumentation used in the tracer study test is critical in the evaluation of the tracer study data. The instruments of interest include the chemical test equipment as well as flow meters. Please provide the following information on tracer study data and instrumentation:
	+ Equipment summary and calibration information for the equipment used in the tracer study test.
	+ Attach the calibration check field notes (a check on the validity of the current calibration, not a recalibration).
* Please provide a copy of field data sheets. Each data sheet should include the following:
	+ The name of the reactor tested, the name of the recorder, and the date;
	+ The instrument(s) from which the data was obtained (flow meter, analytical equipment);
	+ The temperature of the water before tracer injection and at each tracer sampling point. If the water temperature varies significantly, then the temperature should be monitored throughout the test.
	+ The background concentration of the tracer should be monitored in the water before tracer injection periodically throughout the test.
* If an electronic spreadsheet is used, please provide a copy of the “live” (unlocked and enabled) spreadsheet. The spreadsheet should include a summary tab that lists the equations used in the spreadsheet.
* Please provide photos of the tracer test including reactor being tested, equipment set-up, tracer injection location, and sampling location(s).