The Water Supply Technical Advisory Committee

- A volunteer committee of the Ohio Fire Chiefs’ Association
- Comprised of 24 members from all parts of the state
- Most members are from volunteer or combination departments serving rural communities
WSTAC Mission

The committee promotes:

- Development of model procedures and techniques for rural water supply
- Standardization of water supply operations and terminology throughout the state
- Creation and maintenance of regional and statewide mutual aid systems

In support of this, the committee:

- Researches tactical and technical innovations in water supply and shares their findings with the fire service
- Conducts and evaluates water shuttle and relay pumping exercises
- Evaluates apparatus and equipment used for rapid water delivery

“Members of this committee represent communities that are faced with various water supply challenges each day, and are ready to share their experiences and expertise with other communities in an effort to improve their ability to provide firefighting water in a timely fashion, and in adequate quantities.”
Current WSTAC Membership Locations

Regions relate to the Ohio Fire Chiefs’ Association Emergency Response Plan (ERP); a statewide mutual aid system.
High-Performing Water Supply Areas
What does WSTAC do?

Training & Coaching:

- WSTAC members attend multiple water supply drills and trainings throughout the state each year
- Members developed and teach a day-long water shuttle operations class each year at the NW Ohio Volunteer Firefighter Association weekend

In 2015:

- WSTAC represented at eight water supply training events around Ohio (teaching and/or coaching/evaluating)
- WSTAC hosted a two-day water supply workshop by GBW Associates (from Maryland)
What does WSTAC do?

Mutual Aid Planning:

- Developed a new Ohio water tender resource typing standard to support the Fire Chiefs’ statewide mutual aid system
- Developed system to support non-traditional water supply assignments (such as for Toledo’s water system following the Lake Erie toxic algae bloom)
<table>
<thead>
<tr>
<th>Component</th>
<th>Metric</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<tbody>
<tr>
<td>Tank Capacity</td>
<td>Gallons</td>
<td>3000</td>
<td>2400</td>
<td>1800</td>
<td>1000</td>
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<td>Fill Rate</td>
<td>GPM</td>
<td>1000</td>
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<td>1000</td>
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<td>Off-Load Rate</td>
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<td>Portable Tank</td>
<td>Presence</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>NFPA 1901</td>
<td>Compliance</td>
<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
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</table>

**Comments:**
- Apparatus shall carry one or more portable water tanks with a combined capacity sufficient to hold its rated tank capacity.
- Apparatus crew shall consist of at least two personnel, at least one of which is licensed to operate the apparatus.
- NFPA 1901 compliance refers to edition of standard in effect at time of apparatus manufacture.
- Additional capabilities to specify when ordering: Rated fire pump; pump and roll capability; vacuum design.
### Ohio Fire Chiefs’ Association – Emergency Response Plan

**Water Tender Resource Typing Standard**

<table>
<thead>
<tr>
<th>Type</th>
<th>Minimum Tank Capacity (gal)</th>
<th>Representative Sizes (rated tank capacity)</th>
<th>1</th>
<th>3</th>
<th>5</th>
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<tr>
<td>4</td>
<td>1000</td>
<td>1000, 1200, 1500</td>
<td>125-175</td>
<td>75-125</td>
<td>50-100</td>
<td>25</td>
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<tr>
<td>3</td>
<td>1800</td>
<td>1800, 2000, 2200</td>
<td>200</td>
<td>150</td>
<td>100-125</td>
<td>75</td>
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<tr>
<td>2</td>
<td>2400</td>
<td>2400, 2500</td>
<td>225</td>
<td>175</td>
<td>125-150</td>
<td>100</td>
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<tr>
<td>1</td>
<td>3000</td>
<td>3500, 4000</td>
<td>250</td>
<td>200</td>
<td>150</td>
<td>125</td>
</tr>
</tbody>
</table>

**Shuttle Route Distance (miles)**

**Expected Continuous Flow Contribution (CFC) (gpm)**

**Model Assumptions (Standard Conditions):**

- **Fill Site:** Water source flows 1000 gpm; handling time is one minute (maneuvering, hook-up, etc.); apparatus fills at 1000 gpm
- **Dump Site:** Handling time is one minute (maneuvering, hook-up, etc.); apparatus dumps at 1000 gpm
- **Travel Conditions:** Average speed is 35 mph with 0.65 minute modifier added per NFPA 1142
What does WSTAC do?

Support Innovation:

- Observe, test and evaluate new technologies and techniques
- Disseminate findings to Ohio’s fire service
Single-Lane Dump Tanks (SLT)

- Concept originated in Ross County, Ohio
- Narrow rectangular shape keeps tanks from blocking narrow rural roadways
- Can be positioned in-line with pumper; may be equipped with built-in drafting flange
- Tanks are same width as pumper, and same volume as equivalent square tank
Single-Lane Tank

Traditional Square Tank
Single-Lane Tanks in Action
Drone video of Colerain Twp water shuttle drill, Ross Co., Ohio (Sept 2015)
“Type 2” Single-Lane Tank (hexagonal)
Vacuum Tankers

- Tanker apparatus loaded and unloaded using a vacuum system (similar to septic trucks)
- May be equipped with rated fire pump in addition to vacuum system
- Reduces staffing demand by eliminating need for fill site pumper
- One of only two manufacturers located in Ohio (Fir-O-Vac in Apple Creek)
Vacuum tanker drafting from pond through 120 feet of hard suction; water reached apparatus @26 seconds
(Colerain Twp water shuttle drill, Ross Co, Ohio; Sep 2015)
Vacuum Tanker in Action
Drone video of Colerain Twp water shuttle drill, Ross Co., Ohio, Sept 2015
Automatic Air Primers
Footage of tests conducted by GBW Associates and Trident (the manufacturer)
Automatic Air Primers
Footage of tests conducted by GBW Associates and Trident (the manufacturer)
WSTAC: What’s Next?

Water Supply Planning Tools

- Water supply planning worksheet already developed
- Water supply planning desktop application is under development ("WaSP" = Water Supply Planner); a user-friendly, stand-alone, MS Access based database system
- Expanding water supply best practices from existing centers of excellence to rest of the state
**WSTAC Assistance Model (Draft Version)**

- Systematic process for taking a mutual aid association (MAA) from “zero” to “big water” in about 3 years
- “Building-block” approach adapted from Homeland Security Exercise & Evaluation Program (HSEEP)

<table>
<thead>
<tr>
<th>Phase 1 “Orient” 0-3 months</th>
<th>Phase 2 “Plan” 3-18 months</th>
<th>Phase 3 “Refine” 18-36 months</th>
<th>Phase 4 “Perform” 36+ months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seminar(s)</td>
<td>Workshop(s)</td>
<td>Tabletop Exercise</td>
<td>Functional Exercise</td>
</tr>
<tr>
<td>Classroom instruction led by WSTAC members to orient local staff to basic concepts and prepare for more advanced phases</td>
<td>Committee meetings facilitated by WSTAC, convened for the purpose of developing initial SOPs and agreements</td>
<td>Scenario-driven exercise for key staff facilitated by WSTAC, designed to test mutual aid and dispatch systems under controlled conditions</td>
<td>Hands-on field exercise designed to test all components of the water supply system and related plans under realistic conditions, with evaluation and coaching by WSTAC</td>
</tr>
</tbody>
</table>

**Who:** Officers, firefighters, dispatch

**What:**
- Familiarization with basic concepts and best practices
- Possible additional advanced, officer-level sessions

**Outcome:**
- Identify Water Supply Officers (WSO)
- Form committees (water supply operations, dispatch procedures, mutual aid planning, etc.)

**Who:** Committees

**What:**
- Develop initial SOPs
- Develop initial mutual aid plan

**Outcome:**
- Initial operations SOPs (fill site, dump site, water tender operations, etc.)
- Initial dispatch SOPs
- Initial mutual aid agreement

**Who:** Chief officers, WSOs, dispatch

**What:**
- Test dispatch SOPs and mutual aid plan

**Outcome:**
- Refine dispatch SOPs and mutual aid plan

**Drills**

_Narrowly-focused, hands-on field exercises designed to test specific SOPs with evaluation and coaching by WSTAC members_

**Who:** Operations personnel

**What:**
- Test operations SOPs separately, under realistic field conditions (fill site drill, dump site drill, etc.)

**Outcome:**
- Refine operations SOPs
- Identify equipment and staffing needs

**Who:** Officers, firefighters, dispatch

**What:**
- Validate the entire water supply system under realistic field conditions

**Outcome:**
- Demonstrate water supply system effectiveness
- Maintain skills
- Integrate new staff and equipment
- Continually refine SOPs and mutual aid plans
Highway Hydraulics
Hands-On Exercise
Water Shuttles: When to Establish?

- Needed fire flow (GPM) cannot be met by water carried on first-due apparatus (engines and water tenders)
- Incident is outside hydranted area (or to supplement a weak hydrant system)
- Relay operation would not be feasible (distance, time or resource limits; technical capability)
Water Shuttle

Advantages

- Water delivery rates in excess of 1000 GPM can be achieved
- Flexible and robust way to achieve water supply
- Cost-effective water supply system for rural areas (vs. municipal water system)
Water Shuttle Challenges

- Requires specialized equipment, training and procedures (SOPs/SOGs)
- Significant pre-incident planning required to be effective
- Risk exposure for firefighters: Tanker rollovers; backing apparatus at dump site
Water Supply

Empty Tankers

Dump Site

Relay Pumper

Suppression Operations

Full Tankers

WATER SUPPLY

Drafting Pumper

Fill Site
Water Supply

Empty Tankers

Relay Pumper

Full Tankers

Suppression Operations

Dump Site

Water Shuttle

Drafting Pumper

Fill Site

WATER SUPPLY
Empty Tankers

Fill Site

WATER SUPPLY

Drafting Pumper

WT

Full Tankers

Dump Site

Suppression Operations

Relay Pumper

Eng
In a water shuttle: **Time is Water**

Time must be reduced whenever possible, but never at the expense of safety.
Water Supply Sources

Pressurized Sources
- Municipal hydrant systems
- Irrigation pivots
- Elevated on-site tanks

Static Sources (= no pressure)
- Ponds and lakes (natural and man-made)
- Streams (creeks, rivers, etc.)
- Ditches
- Cisterns
- Swimming pools
Fill Site Time Costs

Total Fill Site Time = \( \text{Fill Time} + \text{Handling Time} \)

Fill Time
- Water tender tank capacity
- Water tender maximum fill rate
- Water source fill rate
- Drafting engine/pump flow rate

Handling Time
- Skill of fill site crew
- Capability of water tender driver
- Fill site layout
Reducing Fill Site Restrictions

Water Source Improvements

- Install dry hydrants, sumps, and other drafting facilitators

- Design dry hydrants to support high flows – design for the future, not to meet today’s minimum requirements (at least 1000 gpm design flow)

- Maintain and flow-test dry hydrants once installed
Reducing Fill Site Restrictions

Handling Time Improvements

- Fill Site Layout: Use one-way traffic flow and eliminate need for backing
- Use manifold (rural hitch), but only fill one water tender at a time
- Drafting engine/pump capability does not create chokepoint
- Fill site crew is well-trained and experienced
- Install Automatic Air Primers on draft pumpers
Reducing Fill Site Restrictions

Fill Time Improvements

- Fill direct to tank if possible, not through a pump
- Ensure tank is properly vented
- Fill from ground level if possible
- Driver should remain in cab, ready to leave – fill site crew does all work
Dump Site Operations
Dump Site Time Costs

Total Dump Site Time = Dump Time + Handling Time

Dump Time

- Water tender tank capacity
- Water tender maximum dump rate

Handling Time

- Skill of dump site crew
- Capability of water tender driver
- Dump site design/layout
- Water tender dump configuration (side/rear, multiple dumps)
Reducing Dump Site Restrictions

Flow Management

- Maximize use of side dumps; minimize need to back tenders

- Don’t dump down to the “last drop” – only use most efficient flow

- Favor more efficient water tenders – allow them to “leap frog” those that dump slower
Reducing Dump Site Restrictions

Handling Time Improvements

- Dump Site Layout: One-way traffic flow and minimize backing
- Set up adequate drop tanks to handle flow
- Dump site crew well-trained and experienced
Reducing Dump Site Restrictions

Dump Time Improvements

- Ensure tank is properly vented
- Use largest possible dump outlet
- Use multiple dump outlets if possible
- Driver should remain in cab, ready to leave – dump site crew does all work
Reducing Dump Site Restrictions

Dump Tanks

- Always use at least two portable dump tanks (more is better)
- Keep largest tank full by transfer of water from smaller tanks (using jet siphons)
- Use single lane tanks to reduce congestion at dump site
Reducing Dump Site Restrictions

Locating Dump Sites

- If possible, pre-plan dump sites for limited-access developments and long driveways
- Be prepared to relay pump water from dump site to attack engines via LDH
- Dump site operations and water tender traffic will interfere with suppression operations and EMS access
Shuttle Route Time Costs

Total Travel Time = 
Route Distance x (Minutes/Mile)

Route Distance
- Depends on location of water supply sources (fill sites) and incident (dump site)

Travel Speed
- Road conditions (weather)
- Road characteristics (surface, slope, curves, etc.)
- Capability of apparatus
Shuttle Route Safety

Route Layout
- One-way (loop) routes
- May be longer, but safety is increased

Road Conditions
- Shortest route may not be suitable for repetitive tanker traffic
- Use best road for the job, even if longer
Reducing Travel Time

More Fill Sites

- The more fill sites available, the less time water tenders have to spend on the road
- During Incident: Scout for closer water supply if possible
- Long-Term: Locate and/or develop as many high-capacity water sources as possible
“Drive Faster” is **NEVER** the right answer

Dresser-Osceola-Garfield FD (WI) 3200-gal tanker following rollover accident, 23 Mar 2010; photo source URL: http://www.presspubs.com/article_4a0a61c5-bfbe-5a3b-be47-5df42063d329.html?mode=story
Water Tenders

a.k.a. Tankers ... sorry, NWCG
Water Tender Flow Factors

Critical Shuttle Factors

- Tank capacity (gallons)
- Dump Rate (gpm)
- Fill Rate (gpm)
- Design (conventional vs. vacuum)
Tank Capacity

- Rated Capacity vs. Effective Capacity
- Large is not always the best choice – local conditions drive choice
- Larger tanks have longer dump and fill times
Water Tender
Flow Factors

Dump Rate

- How quickly can the tank be emptied?
- Make sure large tanks are designed with high dump rates
- NFPA 1901 calls for a minimum of 1000 gpm; more is always better
- Considerations:
  - Tank design
  - Dump chute design
  - Dump chute placement
  - Dump chute size
Fill Rate

- How quickly can the tank be filled?
- Large tanks should be designed to allow high fill rates
- NFPA 1901 calls for a minimum of 1000 gpm
- Maximum fill rate limited by manufacturer warranty on tanks in many cases
Conventional Design

- Modern designs use gravity to rapidly dump water via large chutes
- Older designs may use jet assist or pump water off
- May have rated pump (or not)
- Should have rear *and* side dumps (or at least 3-way directional dump on rear)
- Generally: Effective tank volume is 90% of rated tank volume (due to spillage and inefficiencies as dump rate declines with decreased pressure head)
Conventional Water Tenders

Best Design Practices

- Ability to dump side and rear (or directional dump on rear)
- Multiple side dumps
- Remote-controlled dumps (driver stays in cab)
- Automatic venting
- Large-diameter, direct-to-tank fill connection
- “Fireman’s Friend” type valve on fill connection (eliminates need to manually operate fill valve)
- Fill connection accessible from ground
Water Tender Design

Vacuum Design

- Can perform all functions of conventional water tenders
- 100% of tank volume usable (effective = rated capacity)
- Consistent dump rate

- Fill site engine not required; important for areas with limited available staffing
- Functionality may offset higher up-front costs in the long run
Effective Tank Capacity

Dump Rate (GPM)

Time

Conventional

Vacuum
Keep Water Tenders Moving

$175,000 is a lot to pay for a portable tank
Flow Calculation Exercise
## Water Shuttle Tactical Resources Worksheet

### 1. Required Water Supply
- **Water Supply Zone / Incident:**
- **Minimum Water Supply:**
- **Water Delivery Rate:**

### 2. Fill Site
- **Fill Site:**
- **Drafting Engine:**
- **Exploitable Volume (VEx):**
- **Engine Flow Rate (EQ):**

### 3. Dump Site
- **Dump Site:**
- **Dump Site Crew Handling Time (HTD):**
- **Flow Calculations:**

### 4. Route
- **Route:**
- **Travel Speed (mph):**
- **Total Distance (miles):**
- **Distance x (60 / mph) = minutes:**

### 5. Water Tenders
<table>
<thead>
<tr>
<th>No.</th>
<th>Unit Designator</th>
<th>Nominal Tank Capacity (RV)</th>
<th>Residual Water Factor (k) Conv = 0.9 Vac = 1.0</th>
<th>Adjusted Tank Capacity (V) RV x k</th>
<th>Fill Rate (RF) gpm</th>
<th>Dump Rate (RD) gpm</th>
<th>Restricted Fill Rate (FSR) lesser of FSQ, EQ &amp; RF</th>
<th>Fill Time (V/FSR)</th>
<th>Handling Time HTF</th>
<th>Total Fill Time (TF) (V/FSR)+HTF</th>
<th>Dump Time (V/RD)</th>
<th>Handling Time HTD</th>
<th>Total Dump Time (V/RD)+HTD</th>
<th>Total Travel Time TR TF+TD+TR</th>
<th>Continuous Flow (V/T)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</tbody>
</table>

### 6. Fill Site Time
- **Total Time (T):**

### 7. Dump Site Time
- **Total Time (T):**

### 9. Flow Calculations
- **Total Shuttle Flow (GPM):**

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**Ohio Fire Chiefs’ Association**

**Water Supply Technical Advisory Committee**


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Cannot exceed Fill Site Flow Rate (FSQ)
Section 1. Required Water Supply

What Do We Need?

Water Supply Zone: Maple Ridge Estates subdivision (MRE)

Min. Water Supply: 11,700 gallons
Water Delivery Rate: 750 gpm
(per NFPA 1142)
1. Required Water Supply

<table>
<thead>
<tr>
<th>Water Supply Zone / Incident</th>
<th>Maple Ridge Estates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum Water Supply</td>
<td>11,700</td>
</tr>
<tr>
<td>Water Delivery Rate</td>
<td>750</td>
</tr>
</tbody>
</table>
Section 2. Fill Site

Available Water

Fill Site:
29-A
(Mad River @ CR-29)

Exploitable Volume:
unlimited

Maximum Flow Rate (FSQ):
1500 gpm
Section 2. Fill Site (continued)

**Drafting Engine**

Drafting Engine:
E-382
(mutual aid pumper)

Engine Flow Rate (EQ):
1,250 gpm

Fill Site Crew Handling Time:
1.5 minutes
### 2. Fill Site

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Fill Site</td>
<td>Drafting Engine</td>
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<tr>
<td>29-A</td>
<td>E-382</td>
</tr>
<tr>
<td>Exploitable Volume (VEx)</td>
<td>Engine Flow Rate (EQ)</td>
</tr>
<tr>
<td>unlimited</td>
<td>1,250</td>
</tr>
<tr>
<td>Maximum Flow Rate (FSQ)</td>
<td>Fill Site Crew Handling Time (HTF)</td>
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<tr>
<td>1500</td>
<td>1.5</td>
</tr>
</tbody>
</table>
Section 3. Dump Site

Dump Site:
MRE-1
(pre-planned site)

Dump Site Crew Handling Time:
1.0 minute
### 3. Dump Site

<table>
<thead>
<tr>
<th>Dump Site</th>
<th>MRE-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dump Site Crew Handling Time (HTD)</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Section 4. Shuttle Route

Route Name:
HT-8
(pre-planned one-way loop)

Total Distance:
4.9 miles

Travel Speed:
35 mph
# 4. Shuttle Route

<table>
<thead>
<tr>
<th>Route</th>
<th>Travel Time (TR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HT-8</td>
<td>4.9 x 1.7</td>
</tr>
</tbody>
</table>

- **Total Distance (miles):** 4.9 miles
- **Travel Speed (mph):** 35 mph

8.4 minutes
## Section 5. Water Tenders

### First Alarm Assignment

<table>
<thead>
<tr>
<th>Unit</th>
<th>Nominal Tank Capacity (gal)</th>
<th>Design</th>
<th>Fill Rate (gpm)</th>
<th>Dump Rate (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanker 111</td>
<td>1,814</td>
<td>Vacuum</td>
<td>844</td>
<td>1,400</td>
</tr>
<tr>
<td>Tanker 21</td>
<td>1,994</td>
<td>Conventional</td>
<td>814</td>
<td>3,365</td>
</tr>
<tr>
<td>Tanker 81</td>
<td>2,306</td>
<td>Conventional</td>
<td>860</td>
<td>1,186</td>
</tr>
</tbody>
</table>
## 5. Water Tenders

<table>
<thead>
<tr>
<th>No.</th>
<th>Unit Designator</th>
<th>Nominal Tank Capacity (RV)</th>
<th>Residual Water Factor (k)</th>
<th>Adjusted Tank Capacity (V)</th>
<th>Fill Rate (RF)</th>
<th>Dump Rate (RD)</th>
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<tbody>
<tr>
<td>1</td>
<td>Tanker 111</td>
<td>1,814</td>
<td>1.0</td>
<td>1,814</td>
<td>844</td>
<td>1,400</td>
</tr>
<tr>
<td>2</td>
<td>Tanker 21</td>
<td>1,994</td>
<td>0.9</td>
<td>1,795</td>
<td>814</td>
<td>3,365</td>
</tr>
<tr>
<td>3</td>
<td>Tanker 81</td>
<td>2,306</td>
<td>0.9</td>
<td>2,075</td>
<td>860</td>
<td>1,186</td>
</tr>
</tbody>
</table>
Section 6. Fill Site Time

**Handling Time + Fill Time**

**Restricted Fill Rate:**

*What is the chokepoint?*

- Fill Site Maximum Flow Rate (1500 gpm)
- Engine Flow Rate (1250 gpm)
- Tanker Rate of Fill (depends on unit)

**Fill Time (minutes):**

Adjusted Tank Capacity ÷ Restricted Fill Rate

**Fill Site Handling Time (minutes):**

- Time to maneuver, hook up, etc.
- Same for all water tenders
### 6. Fill Site Time

<table>
<thead>
<tr>
<th>Restricted Fill Rate (FSR)</th>
<th>Fill Time</th>
<th>Handling Time</th>
<th>Total Fill Time (TF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>lesser of FSQ, EQ &amp; RF</td>
<td>(V/FSR)</td>
<td>HTF</td>
<td>(V/FSR)+HTF</td>
</tr>
<tr>
<td>844</td>
<td>2.1</td>
<td>1.5</td>
<td>3.6</td>
</tr>
<tr>
<td>814</td>
<td>2.2</td>
<td>1.5</td>
<td>3.7</td>
</tr>
<tr>
<td>860</td>
<td>2.4</td>
<td>1.5</td>
<td>3.9</td>
</tr>
</tbody>
</table>
Section 7. Dump Site Time

Handling Time + Dump Time

Dump Time (minutes):
Adjusted Tank Capacity ÷ Dump Rate

Dump Site Handling Time (minutes):
- Time to maneuver, open dumps, etc.
- Same for all water tenders
### 7. Dump Site Time

<table>
<thead>
<tr>
<th>Dump Time</th>
<th>Handling Time</th>
<th>Total Dump Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>(V/RD)</td>
<td>HTD</td>
<td>(V/RD)+HTD</td>
</tr>
<tr>
<td>1.3</td>
<td>1.0</td>
<td>2.3</td>
</tr>
<tr>
<td>0.5</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>1.7</td>
<td>1.0</td>
<td>2.7</td>
</tr>
</tbody>
</table>
Section 8. Travel Time

Travel Time (minutes):
- Route Distance \( \times (60 \div \text{Travel Speed}) \)
- Time required to travel entire route
- Same for all units

<table>
<thead>
<tr>
<th>8. Travel Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Total Travel Time</td>
</tr>
<tr>
<td>TR</td>
</tr>
<tr>
<td>8.4</td>
</tr>
<tr>
<td>8.4</td>
</tr>
<tr>
<td>8.4</td>
</tr>
</tbody>
</table>
Section 9. Flow Calculations

*What is the total flow?*

**Total Time:**
- Fill Time + Dump Time + Travel Time

**Continuous Flow Rate (by Water Tender):**
- Adjusted Tank Capacity ÷ Total Time
- Sum all for total shuttle flow (gpm)
### 9. Flow Calculations

<table>
<thead>
<tr>
<th>Total Time (T)</th>
<th>Continuous Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>TF+TD+TR</td>
<td>(V/T)</td>
</tr>
<tr>
<td>14.3</td>
<td>126</td>
</tr>
<tr>
<td>13.6</td>
<td>132</td>
</tr>
<tr>
<td>15.1</td>
<td>138</td>
</tr>
</tbody>
</table>

**TOTAL SHUTTLE FLOW (GPM)**: 396

*Cannot exceed Fill Site Flow Rate (FSQ)*
### Will This Shuttle Work?

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Needed</th>
<th>Delivered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Water Supply (gallons)</td>
<td>11,700</td>
<td>Unlimited</td>
</tr>
<tr>
<td>Water Delivery Rate (gpm)</td>
<td>750</td>
<td>396 ×</td>
</tr>
</tbody>
</table>

**What can we change?**
<table>
<thead>
<tr>
<th>Needed</th>
<th>Delivery Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>396 gpm</td>
</tr>
<tr>
<td>Add Two x 2,000 gallon</td>
<td>644 gpm (+248 gpm / +63%)</td>
</tr>
<tr>
<td></td>
<td><em>Each adds 124 gpm</em></td>
</tr>
<tr>
<td>Add Two x 3,500 gallon</td>
<td>762 gpm (+366 gpm / +92%)</td>
</tr>
<tr>
<td></td>
<td><em>Each adds 183 gpm</em></td>
</tr>
<tr>
<td>Needed</td>
<td>Delivery Rate</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Current Fill Site Handling Time: 1.5 minutes</td>
<td>396 gpm</td>
</tr>
<tr>
<td>Decrease to 0.5 minutes</td>
<td>426 gpm (+30 gpm / +8%)</td>
</tr>
</tbody>
</table>
## Drive Faster?

<table>
<thead>
<tr>
<th>Needed</th>
<th>Delivery Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current: 35 mph</td>
<td>396 gpm</td>
</tr>
<tr>
<td>Increase to 45 mph</td>
<td>455 gpm</td>
</tr>
<tr>
<td></td>
<td>(+59 gpm / +15%)</td>
</tr>
<tr>
<td>Increase to 55 mph</td>
<td>503 gpm</td>
</tr>
<tr>
<td></td>
<td>(+107 gpm / +27%)</td>
</tr>
<tr>
<td>Needed</td>
<td>Delivery Rate</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Current: 4.9 miles</td>
<td>396 gpm</td>
</tr>
<tr>
<td>Decrease to 2.5 miles</td>
<td>555 gpm (+159 gpm / +40%)</td>
</tr>
<tr>
<td>Decrease to 1.0 mile</td>
<td>743 gpm (+347 gpm / +88%)</td>
</tr>
</tbody>
</table>
### What’s the Right Answer?

**Need 354 gpm more**

<table>
<thead>
<tr>
<th>Change</th>
<th>Result</th>
<th>Risk</th>
<th>Difficulty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>396 gpm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Add Two x 2,000 gallon</td>
<td>+248 gpm</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Add Two x 3,500 gallon</td>
<td>+366 gpm</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Fill Site Handling</td>
<td>+30 gpm</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Drive Faster (45 mph)</td>
<td>+59 gpm</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Drive a lot Faster (55 mph)</td>
<td>+107 gpm</td>
<td>Very High</td>
<td>Low</td>
</tr>
<tr>
<td>Closer Fill Site</td>
<td>+159 gpm</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>A Lot Closer Fill Site</td>
<td>+347 gpm</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
Ohio Fire Chiefs’ Association

Water Supply Technical Advisory Committee

http://www.ohiofirechiefs.org/aws/OFCA/pt/sp/water_TAC

Presentation Developed By: Jeremy Keller, Bellefontaine Fire & EMS (October 2015)