Portable Pumps and Water Use S-211

Instructor Guide

MARCH 2012

NFES 003026

CERTIFICATION STATEMENT

on behalf of the

NATIONAL WILDFIRE COORDINATING GROUP

The following training material attains the standards prescribed for courses developed under the interagency curriculum established and coordinated by the National Wildfire Coordinating Group. The instruction is certified for interagency use and is known as:

Portable Pumps and Water Use, S-211
Certified at Level I

This product is part of an established NWCG curriculum. It meets the requirements of the NWCG Curriculum Management Plan and has received a technical review and a professional edit.

Member NWCG and Operations and Workforce Development Committee Liaison

Date 03.01.2012

Chairperson, Operations and Workforce Development Committee

Date 3/28/12

Portable Pumps and Water Use

S-211

Instructor Guide

MARCH 2012

NFES 003026

Sponsored for National Wildfire Coordinating Group (NWCG) publication by the NWCG Operations and Workforce Development Committee. The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader and does not constitute an endorsement by the NWCG of any product or service to the exclusion of others that may be suitable.

Comments regarding the content of this publication should be directed to:
National Interagency Fire Center, Fire Training, 3833 South Development Avenue, Boise, Idaho 83705.
E-mail: nwcg_evaluation@nifc.blm.gov

Additional copies of this publication may be ordered from National Interagency Fire Center,
ATTN: Great Basin Cache Supply Office, 3833 South Development Avenue, Boise, Idaho 83705.
Order publication number: NFES 003026.

NWCG OPERATIONS AND WORKFORCE DEVELOPMENT COMMITTEE POSITION ON COURSE PRESENTATION AND MATERIALS

The recommended hours listed in the FMCG are developed by Subject Matter Experts based on their estimation of the time required to present all material needed to adequately teach the unit and course objectives. The hours listed may vary slightly due to factors such as number of students, types and complexity of course activities, and the addition of local materials.

NWCG does not approve of course delivery varying greatly from the recommended course hours. Instructors and students are cautioned that in order to be recognized as an NWCG certified course, certain guidelines must be followed:

- Lead instructors are encouraged to enhance course materials to reflect the conditions, resources and policies of the local unit and area as long as the objectives of the course and each unit are not compromised.
- Exercises can be modified to reflect local fuel types, resources and conditions where the student will be likely to fill incident assignments. The objectives and intent of the exercises must remain intact.
- Test questions may be added that reflect any local information that may have been added to the course. However, test questions in the certified course materials should not be deleted to ensure the accurate testing of course and unit objectives.
- Test grades, to determine successful completion of the course, shall be based only on the questions in the certified course materials.

If lead instructors feel that any course materials are inaccurate, that information should be submitted either by accessing the online feedback form at training.nwcg.gov or e-mail to NWCG Training at nwcg_evaluation@nifc.blm.gov. Materials submitted will be evaluated and, where and when appropriate, incorporated into the appropriate courses.

COURSE LENGTH FOR NWCG COURSES

Recommended course hours and the "NWCG Position on Course Presentation and Materials" above will be adhered to by the course instructors (see below for exception for criteria based courses).

- Unit times represent the allotted time to teach the unit and complete the exercises, simulations, and tests.
- Recommended course hours are given to help the students and the course coordinator with planning travel, room reservations, and facilities usage. This represents the time estimated to present the NWCG provided materials including time for breaks, lunch periods, set-up for field exercises or simulations, etc.
- Actual times for both the unit and the course may vary based on number of students, types and complexity of course activities, and the addition of local instructional materials.

If the course is criteria based, e.g., L-380, and has been developed using NWCG course criteria, minimum course hour requirements have been established and must be adhered to by the course developer and course instructors.

Course hours for all NWCG courses can be found in the Field Manager's Course Guide (www.nwcg.gov/pms/training/training.htm). If the hours are a minimum versus recommended they will be stated as such.

PREFACE

Portable Pumps and Water Use, S-211, is identified training in the Wildland Fire Qualification Subsystem of the National Interagency Incident Management System (NIMS). This course was developed by an interagency group of subject matter experts with direction and guidance from the National Interagency Fire Center (NIFC), Fire Training, under the authority of NWCG. The primary participants in this development effort were:

BUREAU OF LAND MANAGEMENT

Hector Basso – National Interagency Fire Center, Boise, ID
Chris Swisher – Alaska Fire Service, Ft. Wainwright, AK

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

Brian Pisarek – Aitkin, MN

U.S. FOREST SERVICE

Kim Valentine – Mt. Hood National Forest, Dufur, OR

NWCG Training BRANCH

NWCG Development Unit, Evaluation Unit, and Instructional Media Unit

The NWCG appreciates the efforts of these personnel and all those who have contributed to the development of this training product.

CONTENTS

COURSE INSTRUCTIONS

This section contains instructions and information essential to the course coordinator and instructors in making an effective presentation. Cadre members must read this section and be thoroughly familiar with course procedures and material before presentation.

I. INTRODUCTION

The S-211, Portable Pump and Water Use, course requires 16 to 20 hours for presentation. This course is designed to meet the training needs of a Firefighter Type 1 or Incident Commander Type 5 on an incident as outlined in the Wildland Fire Qualification System Guide (PMS 310-1) and the position task books developed for these positions.

The Wildland Fire Qualification System Guide provides guidance and a national wildfire standard for establishing minimum training, skills, knowledge, experience, and physical fitness requirements for the participating agencies of the NWCG.

The Course Coordinator's Guide (PMS 907) contains general information for presentation of NWCG courses. The course coordinator and instructors should be thoroughly familiar with this guide (online at www.nwcg.gov/pms/training/training.htm).

To ensure that the most up-to-date material is being presented, instructors are encouraged to refer to the NWCG Operations and Workforce Development Committee website. This website contains current updates for all NWCG courses (go to http://training.nwcg.gov/sect_course_updates.html and select the link for the course you are coordinating or instructing).

II. COURSE OBJECTIVES

Course objectives are stated in broad terms that define what students will be able to accomplish after completing the course.

At the successful completion of this course, students will be able to:

- Demonstrate knowledge and skills to design, set up, operate, troubleshoot, and shut down portable water delivery systems.

III. INSTRUCTOR PREREQUISITES

Refer to the Field Manager's Course Guide (PMS 901-1) for instructor prerequisites specific to this course (online at www.nwcg.gov/pms/training/training.htm).

This is a 200-level course. In addition to the course-specific instructor prerequisites, all instructors are required to have 32 hours of instructor training such as Facilitative Instructor (M-410) or an equivalent course, as stated in the Field Manager's Course Guide.

IV. INSTRUCTOR PREPARATION AND COURSE COORDINATION

A. General Information

The Course Coordinator's Guide (PMS 907) contains general information for presentation of NWCG courses. The course coordinator and instructors should be thoroughly familiar with this guide (online at www.nwcg.gov/pms/training/training.htm).

B. Test the Equipment

Test the computer and projector before class each day to ensure compatibility with software.

C. PowerPoint Presentations

Refer to the #READ ME file, located on the CD which provides information on:

- Minimum System Requirements to Successfully Run Microsoft PowerPoint 2010 Presentations
- Editing the Original PowerPoint 2010 File
- Troubleshooting
- Microsoft PowerPoint Viewer 2010
- References on Creating PowerPoint Slides

Animations

The PowerPoint Presentations for this course contains several animations, including a 3D animation of a commonly used portable pump. Before teaching the course, review the PowerPoint presentations and become familiar with the animations.

D. Exercises or other pertinent information

- Classroom exercises

  There are four classroom exercises. Be sure to review the exercise instructions and supplemental material before teaching the course. Refer to Unit 1 (Portable Water Delivery Systems), Unit 3 (Responsibilities), and Unit 4 (System Design and Hydraulics) for instructions.

- Unit 4 (System Design and Hydraulics)

  This unit must be taught by an instructor who understands hydraulic calculations, has experience using them in the field, and is comfortable teaching the concepts.

- Field exercise

  There is one field exercise where students will obtain experience working with water delivery systems. This exercise requires advanced planning and preparation (for example, making logistical arrangements, and ordering equipment). Refer to Unit 5 (Field Exercise) for instructions.

V. COURSE MATERIALS

See Appendix A for course ordering and support information.

A. Instructor Guide

The Instructor Guide is designed as a teaching aid to assist instructors in presenting the course. Each unit begins with a Unit Overview that outlines the lesson's approximate delivery time, objectives, learning strategy, instructional methods, required materials, instructional aids, and evaluation criteria.

The Unit Presentation follows the Unit Overview, and contains the lesson plan for each unit, shown in a two-column format:

The Outline column contains the technical content for each unit, written in outline format.

- This column contains the lesson content that supports the learning objectives. The column also contains notes to the instructor (directions for conducting an exercise, questions to ask students, etc.), which are in **bold boxes**.

- The Aids & Cues column lists references (slide numbers, handouts, publications, etc.) that remind instructors to display or refer to specific materials.

B. Course Materials CD

The CD contains complete copies of the Instructor Guide, Student Workbook, and Appendixes in bookmarked files in portable document format (pdf).

C. Student Workbook

In most cases, the Student Workbook contains the same course information as the Instructor Guide but without the instructor aids and exercise answers. Student Workbooks should be ordered before the beginning of the course, one for each student.

D. Course Agenda

Sample agendas for the 16-hour course and the 20-hour course are on pages 13 and 14. Revise the agenda as appropriate. The agenda can be inserted into the Student Workbook before the beginning of class. Consider removing timeframes from the agenda that is given to students.

VI. STUDENT TARGET GROUP

This course is for personnel desiring to be qualified as a Firefighter Type 1 or Incident Commander Type 5 or those wanting to learn more about portable pumps and water use.

VII. STUDENT PREREQUISITES

Refer to the Field Manager's Course Guide (PMS 901-1) for current course prerequisites.

VIII. SELECTION LETTER

A selection letter will need to be sent to students who successfully complete or pass the pre-course work or are selected to attend the course. This letter congratulates selected students and should explain class times, dates, and location. Refer to the Course Coordinator’s Guide (PMS 907) for more information on selection letters.

An example course selection letter is located on page 11.

IX. CADRE MEETINGS

Cadre meetings are an opportunity for instructors to meet, review the material, and discuss concerns with the course coordinator or lead instructor. The meetings are critical for instructors who do not have previous experience with the course.

We suggest having a cadre meeting before each day’s course presentation because the relationship of the unit material (changing instructional materials in one unit may affect a later unit).

After each day’s presentation, hold a cadre meeting to discuss concerns and progress. At the end of the course, conduct a final cadre meeting to evaluate instructor performance and suggest modifications for future courses.

X. RECOMMENDED CLASS SIZE

The recommended class size is 20 to 30 students. The recommended student-to-instructor ratio is 10:1. However, if class is large, additional instructors may be needed for the field day.

XI. SPACE AND CLASSROOM REQUIREMENTS

The characteristics of the classroom and supportive facilities have a significant impact on the learning environment. The classroom and field exercise locations should be visited and selected well in advance. Refer to the Course Coordinators Guide (PMS 907) for more information.

A. Classroom

Choose a location and classroom that have the following characteristics:

- Adequate room and flexibility for student work groups and equipment, including supportive facilities such as break areas, restrooms, etc.
- Free from outside interruptions and interferences.
- Controlled lighting, good acoustics, and good ventilation.
- Adequate access to copy and printing services.
- A computer with projector and screen to show electronic presentations.

B. Field Exercise

Refer to Unit 5 (Field Exercise) for instructions on selecting a field exercise location.

XII. STUDENT ASSESSMENT

A. Unit Review Questions

Each unit ends with an oral review of key points in the unit (question and answer session).

B. Final Exam

Students must obtain a score of 70% or higher on the final exam to receive a certificate of completion for the course. The final exam (classroom and field exercise) are worth a total of 100 points.

1. Classroom Final Exam and Answer Key

   Refer to Appendix D for instructions on administering the classroom final exam. The classroom final exam consists of 33 questions, and should be completed within 1 hour. Students will need the IRPG and a friction loss calculator.

2. Field Exercise Final Exam

   Refer to Unit 5 (Field Exercise) for instructions on administering the Field Exercise Final Exam. This exam is worth 30 points.

XIII. COURSE EVALUATION FORMS

Copies of these forms are in Appendix E.

A. Student Training Course Evaluation Form

This is an opportunity for students to comment on the course and the instructors for the purpose of improving future training sessions. Distribute the form at the beginning or end of the course.

B. Training Course Evaluation Form

This is an opportunity for the course coordinator and instructors to comment on course design. These comments are used by the NWCG Training Branch to identify potential problems with courses and as a resource during the course revision process.

XIV. APPENDIXES

The following appendixes are on the Course Materials CD-ROM:

- Appendix A – Course Ordering and Support Information

  This appendix tells you ordering procedures for required components of the course and what additional support materials are needed for course presentation.

- Appendix B – PowerPoint Presentations

- Appendix C – Handouts

  This appendix contains five handouts. Duplicate enough copies for each student to have one copy of each.

- Appendix D – Final Exams and Answer Key

  This appendix contains the Final Examination (Classroom and Field Exercise) and the Classroom Exam Answer Key. There is no answer key for the Field Exercise Final Exam. Duplicate enough copies of the final examination for each student to have one copy.

- Appendix E – Course Evaluation Forms

Portable Pumps and Water Use, S-211
Sample Selection Letter

To: *Student's Name*

From: *Course Coordinator's Name*

Subject: *Course Title, Course #*

Congratulations, you have been selected to attend *Course Title, Course #,* to be held at *(location).* The course will begin promptly at *(time and date)* and end at *(time and date).*

The primary emphasis of this course focuses on duties of *a/an Position* within the Incident Command System.

Please bring the following references to class:

- Unit Leader Position Task Book (initiated at the home unit), located at http://www.nwcg.gov/pms/pms.htm.
- Fireline Handbook(PMS 410-1, NFES 0065), located at http://www.nwcg.gov/pms/pubs/pubs.htm.
- Incident Response Pocket Guide (PMS 461, NFES 1077), located at http://www.nwcg.gov/pms/pubs/pubs.htm.

If you wish to receive a certificate of completion for the course, please do not make travel arrangements to arrive after the scheduled start time or to depart before the scheduled course completion time.

In the event you cannot attend the course, please contact the course coordinator before the beginning of the class. This allows time for notifying students who may who may be on the waiting list to be contacted to fill the vacancy.

If you have any questions please contact the course coordinator, *Name, phone number,* and *email address*.

Portable Pumps and Water Use, S-211

Sample Agenda for 16-hour Course

Day 1

Unit 0 – Introduction .... 15 minutes

Unit 1 – Portable Water Delivery Systems.................................... 15–30 minutes

Unit 2 – Equipment.. 1 hour

Unit 3 – Responsibilities.. 2 hours

Lunch

Unit 4 – System Design and Hydraulics.. 3 hours

Classroom Final Exam.. 1 hour

Cadre Meeting (Review Day 1)

Day 2

Unit 5 – Field Exercise, and Field Exercise Final Exam.................. 8 hours

Lunch

Issue Course Certificates

Cadre Meeting (Course Closeout)

Portable Pumps and Water Use, S-211
Sample Agenda for 20-hour Course

Day 1 – ½ Day

Unit 0 – Introduction .... 15 minutes

Unit 1 – Portable Water Delivery Systems .... 15–30 minutes

Unit 2 – Equipment .... 2 hours

Unit 3 - Responsibilities .... 1 hour

Cadre Meeting (Review Day 1)

Day 2

Unit 3 – Responsibilities (continues) .... 2 hours

Unit 4 – System Design and Hydraulics .... 2 hours

Lunch

Unit 4 – System Design and Hydraulics .... 2 hours

Classroom Final Exam .... 1 hour

Cadre Meeting (Review Day 2)

Day 3

Unit 5 – Field Exercise, and Field Exercise Final Exam .... 8 hours

Lunch

Issue Course Certificates

Cadre Meeting (Course Closeout)

UNIT OVERVIEW

Course Portable Pumps and Water Use, S-211

Unit 0 – Introduction

Time 15 Minutes

Objectives

1. Introduce instructors and students.
2. Discuss course logistics.
3. Present course overview.

Strategy

This unit provides an overview of the course and gives students an idea of what to expect.

Instructional Method

- Informal lecture and discussion with PowerPoint.

Instructional Aids

- ☐ Computer with LCD projector, presentation software, and screen
- ☐ Sign-in sheet
- ☐ Incident Response Pocket Guide (IRPG)
- ☐ Fire Stream/Nozzle Discharge & Friction Loss Calculator

Exercise

- None

Evaluation Method

- None

Outline

I. Introductions

II. Course Logistics

III. Course Overview

Aids and Cues Codes

The codes in the Aids and Cues column are defined as follows:

IG – Instructor Guide	IR – Instructor Reference
SW – Student Workbook	SR – Student Reference
HO – Handout	Slide – PowerPoint

UNIT PRESENTATION

Course: Portable Pumps and Water Use, S-211

Unit: 0 – Introduction

OUTLINE	AIDS & CUES
Unit Title Slide.	Slide 0-1
NWCG Mission Statement Slide.	Slide 0-2

I. INTRODUCTIONS

Introduce instructors and students as appropriate.
Ask students:
- **What experiences do you have with portable water delivery systems?**
- **What expectations do you have for the course?**

II. COURSE LOGISTICS

Discuss as appropriate.

- Breaks – be prompt; return to class at scheduled times.
- Facility – location of vending machines, drinking fountains, restrooms.
- Cell phones and pagers should be turned off
- Smoking policy.
- Message location and available telephones.
- Other local concerns.

OUTLINE	AIDS & CUES
III. COURSE OVERVIEW	
A. Course Objective	Slide 0-3
Demonstrate knowledge and skills needed to design, set up, operate, troubleshoot, and shut down portable water delivery systems.	
Ask students: Does this objective describe what you expected for this course?	
B. Course Structure	Slide 0-4
• Unit 1 – Portable Water Delivery Systems	
• Unit 2 – Equipment	
• Unit 3 – Responsibilities	
• Unit 4 – System Design and Hydraulics	
• Unit 5 – Field Exercise	
C. How Students Will Be Evaluated	Slide 0-5
Students must obtain a minimum score of 70% on the final exam to receive a certificate of completion for the course.	
The final exam consists of a written exam and an evaluation of student participation in the field exercise.	

OUTLINE	AIDS & CUES
D. Course Materials • Student Workbook • Incident Response Pocket Guide (IRPG) **Ensure students have current version of IRPG that contains Water Delivery and Mark 3 information.** • Fire Stream/Nozzle Discharge & Friction Loss Calculator	Slide 0-6
E. Course Evaluation Forms Students are expected to complete a course evaluation form at the end of the course.	Slide 0-7

UNIT OVERVIEW

Course Portable Pumps and Water Use, S-211

Unit 1 – Portable Water Delivery Systems

Time 15–30 Minutes

Objectives

1. Define the ultimate goal of a water delivery system.
2. List two reasons why portable water delivery systems are important for wildland firefighting and prescribed burning.
3. Identify key factors to consider when designing, setting up, and operating a portable water delivery system.

Strategy

This unit provides the "big" picture perspective of water delivery systems, specifically portable water delivery systems.

Instructional Method

- Informal lecture and discussion with PowerPoint.

Instructional Aids

- ☐ Computer with LCD projector, presentation software, and screen
- ☐ Incident Response Pocket Guide (IRPG)
- ☐ Laser pointer

Exercise

- Thirtymile Fire Incident and the Mark 3 Pump

Evaluation Methods

- Oral review session at end of the unit.
- Objectives will be tested in Final Exam (written).

Outline

I. Water Delivery Systems

II. Portable Water Delivery Systems

III. Review

Aids and Cues Codes

The codes in the Aids and Cues column are defined as follows:

IG – Instructor Guide	IR – Instructor Reference
SW – Student Workbook	SR – Student Reference
HO – Handout	Slide – PowerPoint

UNIT PRESENTATION

Course: Portable Pumps and Water Use, S-211

Unit: 1 – Portable Water Delivery Systems

OUTLINE	AIDS & CUES
Unit Title Slide.	Slide 1-1
Click audio icon to hear firefighter story about pumps.	Slide 1-2
Present Unit Objectives.	Slide 1-3
I. WATER DELIVERY SYSTEMS	Slide 1-4
Several types of water delivery systems are used in wildland firefighting. Some examples are portable backpack pumps, lightweight portable pumps, heavy portable pumps, floatable pumps, engines, and helicopter buckets.	Slide 1-5
The goal of all water delivery systems is to provide proper flow and pressure (to the nozzles) to meet the tactical objectives.	Slide 1-6
This course focuses on the <u>high-pressure portable pump delivery systems</u>. Systems range from a relatively simple setup (a single pump and a couple of nozzles) to a complex operation with multiple pumps and many laterals with different crews using them.	Slide 1-7

OUTLINE	AIDS & CUES
II. PORTABLE WATER DELIVERY SYSTEMS	Slide 1-8
A. Portable water delivery systems are used to supply water for: • Hot spotting • Anchor and flank • Wet line • Mop up • Structure protection • Storage and fill tank	Slide 1-9
B. Why Are Portable Water Delivery Systems Important? • Efficient tool for getting water on the fire. • Increase safety of the firefighter: – Limits exposure: dry mopping versus wet mopping – Hold an advancing line with water more efficiently than a dry line. – Quickly reduces heat. • Cost effective compared to other methods such as aircraft, tankers, and engines. • Increase productivity of personnel, for example, allows personnel to cover more line with water.	Slide 1-10

OUTLINE	AIDS & CUES
• Facilitates the achievement of Minimum Impact Suppression Tactics (MIST); for example, a wet line is a less destructive method compared to a dozer line or hand cut line.	
C. Factors to Consider When Designing, Setting Up, and Operating a Portable Water Delivery System	Slide 1-11
Do not go into detail in this section. These factors are discussed later in other units.	
Several factors influence the type of portable system that is needed and how it is set up and operated. This section discusses some of the more important factors.	
1. Tactical objectives	Slide 1-12
The fire tactic directly influences how the water delivery system is designed, set up, and operated. Therefore, it is important to know the tactical objectives.	
What are examples of how tactical objectives impact the delivery system?	
Several possible answers, such as: • **Tactical objectives impact the design of the delivery system – for example, the design for mop up would most likely be different than a design for structure protection.** • **Tactical objectives impact the pressure and flow needed at the nozzle.**	

OUTLINE	AIDS & CUES
2. Personnel resources	Slide 1-13

- Personnel involved with portable water delivery systems include:

Keep this very general – purpose is to give students a heads up on general roles and responsibilities; specific roles and responsibilities are discussed in detail later.

  - The **supervisor** (e.g., IC, DIV) is typically responsible for designing the water delivery system, ordering equipment, being accountable for equipment, and so on.
  - The **pump operator** is responsible for properly setting up a portable pump operation and maintaining a constant water supply.
  - The **nozzle operator** is responsible for mastering the use of the nozzle and determining method to apply water.
  - **Hand crews and other fire line personnel** often help set up and retrieve hose lay.

- How many pump and nozzle operators are needed? What personnel are available? What experience do they have working with pumps?

OUTLINE	AIDS & CUES
• Risk management concerns – such as personal protective equipment (PPE), Lookouts, Communication, Escape Routes, and Safety Zones (LCES), working with fuel, close vicinity to fire.	
3. Equipment resources	Slide 1-14
• What equipment is needed to set up the delivery system?	
Pumps DO break down, and it pays to have a backup pump. Sometimes troubleshooting a pump takes too long, and it would be more efficient to simply set up another pump.	
• What equipment is available? When can it become available?	
• What is the condition of the equipment?	
4. Site characteristics	Slide 1-15
• Water supply	
The water supply is critical to the delivery system. If the water source is not adequate, tactics may need to change.	
– What water sources are available (e.g., creeks, ponds, lakes, and pools)?	

OUTLINE	AIDS & CUES
– Is any approval needed to use the water source, for example, an agreement?	
– Does the water source have enough water to meet the tactical objectives? Can it provide the flow that is need? Is the water source deep enough and clean enough for the pump to work?	
– How far is the water source from the fire or structure?	
• Terrain (e.g., steep hills, level ground)	
The terrain impacts delivery system design and site setup, for example, if the hose lay has to run up a steep hill or if the water source is far away from to the nozzle.	
• Environmental concerns (e.g., invasive species, threatened and endangered species, water contamination)	
5. Fire behavior	Slide 1-16
Examples of fire behavior factors that need to be considered when designing and operating a portable water delivery system include:	
• Fuel characteristics	
• Fire behavior	

OUTLINE	AIDS & CUES
• Weather	
6. Hydraulic feasibility	Slide 1-17
The delivery system has to be hydraulically feasible or water will not be delivered to the nozzle at the proper flow and pressure.	
EXERCISE: Thirtymile Fire Incident and the Mark 3 Pump	Slide 1-18
Purpose: The primary purpose of this exercise is to emphasize the importance of water delivery systems and keeping pumps running.	
Time: 30 minutes – 1 hour	
Format: Individual and large group discussion	
Materials Needed: Thirtymile Fire Incident and the Mark 3 Pump (an excerpt from the Thirtymile Fire Investigation Report).	IR 1-1 SR 1-1
Full report can be found at www.fs.fed.us/t-d/lessons/documents/Thirtymile_Reports/Thirtymile-Final-Report-2.pdf	
Instructions:	
1. Have students read the instructions for this exercise in their Student Workbook:	
Scan the Thirtymile Fire Incident and the Mark 3 Pump excerpt, from the full report, on page 1.13. Focus on those sections that refer to pump(s) – the word "pump" has been underlined in the report.	

OUTLINE	AIDS & CUES
Answer these questions and be prepared to discuss: • What was the purpose of the pumps on the Thirtymile Fire? • Why couldn't the crew keep the pumps running? • What tactical changes were made when they couldn't keep the pumps running? • What were the consequences of pumps not running?	
2. Facilitate a discussion with students regarding the report and the answers to the questions.	
End of Exercise.	
III. REVIEW	Slide 1-19
Review key points in the unit with PowerPoint slides. Answer any questions students have.	
Question 1: What is the ultimate goal of a water delivery system?	Slide 1-20
Answer: To provide proper flow (adequate gpm) and pressure to meet the tactical objectives.	

OUTLINE	AIDS & CUES
Question 2: Why are portable water delivery systems important for wildland firefighting and prescribed burning? **Answer:** • **Significant and efficient tool for getting water on the fire** • **Increase safety of firefighter** • **Cost effective compared to other methods** • **Increase productivity of personnel** • **Facilitate the achievement of MIST**	Slide 1-21
Question 3: What are the key factors to consider when designing, setting up, and operating a portable water delivery system? **Answer:** • **Tactical objectives** • **Personnel resources** • **Equipment resources** • **Site characteristics** • **Fire behavior** • **Hydraulic feasibility**	Slide 1-22
Review Unit Objectives.	Slide 1-23

Thirtymile Fire Incident and the Mark 3 Pump

Below is an excerpt from the Thirtymile Fire Investigation Report. This excerpt highlights specific information in the report that is relevant to the Mark 3 Pump and excludes a significant amount of text, figures, photos, maps, and reference numbers. The official full Thirtymile Fire Investigation Report can be found at this website:

www.fs.fed.us/t-d/lessons/documents/Thirtymile_Reports/Thirtymile-Final-Report-2.pdf

In Memory Of
Tom Craven
Karen FitzPatrick
Jessica Johnson
Devin Weaver

And Dedicated To Those Who Will Be Saved

Summary

On July 10, 2001, the Forest Service Northwest Regulars #6, a Type 2 fire crew, was entrapped by wildland fire. The fire, caused by an abandoned picnic cooking fire, was located 30 miles north of Winthrop, Washington, along the Chewuch River. Fourteen crewmembers and two civilians were involved in the entrapment. The civilians arrived at the entrapment site while trying to exit the area in their truck. Fourteen shelters were deployed. One shelter contained one Forest Service person and the two civilians. Six individuals, four of whom died, deployed approximately 100 feet upslope from the road. The remaining people, including the civilians, deployed on the road. After the initial deployment they relocated to the river. The civilians' vehicle was destroyed by fire. The Forest Service vehicle sustained minor damage, but was drivable. Ten Forest Service personnel and the two civilians survived the burnover.

The following is an overview of the events and actions that took place related to the Thirtymile Fire Incident. This overview is based on interviews with over 40 individuals, and the analysis of dispatch logs, resource orders, medical records, weather conditions, fuel conditions, training records, and equipment performance. Additional detailed information that is relevant to the identification of causal factors that led to this incident is presented in the appendices and in the Findings Section of this report.

Initial Actions

On Monday evening, July 9, 2001, a Canadian Lead Plane (Bird Dog 8), returning to Canada after supporting the Libby South Fire (burning about 20 miles south of Winthrop, Washington), reported seeing a fire near the road along the Chewuch River about 30 miles north of Winthrop. The report, received at 9:26 p. m. , stated that "the fire covered two hectares or five acres with two spots ahead of it." Within thirty minutes a three-person initial attack crew and Engine #704 were dispatched to Action 103 (later named the Thirtymile Fire).

The Chewuch River runs down a deep "V" canyon. Although there is little elevation change along the canyon floor, both sides of the canyon have steep slopes (70% to 100%). The southwest to northeast orientation of the canyon is in alignment with afternoon ridge top and up-canyon winds.

The initial attack crew arrived at the point of origin of the fire a few minutes after 11 p. m.

They estimated the fire was burning in three to eight acres of heavy brush with flame lengths of two to four feet. They could see two spots on the eastside of the river, one near the river and another that was burning actively close to the east slope.

It was later determined that the fire had started as the result of an abandoned picnic cooking fire.

The initial attack crew thought that the fire would grow and unless they could get water on the fire their efforts would be useless. The initial attack crew boss then requested two engines, a Mark III pump, hoses, and at least a 10-person crew. The initial attack crew had four bladder bags, hand tools and a chainsaw.

Engine #704 arrived at the fire about 15 minutes before midnight. The initial attack crew boss offered the Supervisor on Engine #704 the Incident Command (IC) of the fire. The Engine Supervisor refused the IC role since he felt it was beyond what he could handle, it was dark, and he did not know the country very well. It was his assessment that the fire was "20 to 25 acres … with multiple snags and numerous candles." This revised estimate of the fire size and the view that "it will grow, hit the slope and get larger" was passed onto the Okanogan Dispatch by the IC. It was decided to hold at the road until the Entiat Interagency Hotshots (Entiat IHC) showed up.

At about midnight when the Okanogan Dispatch asked the IC if the fire could be let go until the morning, he responded that the fire needed “to be taken care of tonight because if it hits that slope it is going to the ridge top.”

The Entiat IHC was to be located and sent to the fire after working the day on another fire near Spokane, Washington. After bedding down for approximately 30 minutes at the Liberty High School near Twisp, Washington, about 10 miles south of Winthrop, the Entiat IHC was awakened around midnight and sent to the Thirtymile Fire.

Around 1:00 a. m. on Tuesday, July 10th, the Entiat IHC and a pick-up truck with two additional firefighters arrived at the scene. The pick-up truck had a Mark III pump, wye gates, and over 1,000 feet of hose. Although the IC offered pump support, the Entiat IHC Superintendent felt it was not necessary. As a result the three-person initial attack crew, Engine #704, and the pick-up truck departed at 1:30 a. m. The Entiat IHC Supervisor assumed the role of IC a little after 1:00 a. m.

The Entiat IHC began lining the fire between the road and the Chewuch River. Numerous spots were noticed on the east side of the river. The plan of attack was to cross the river, find the spots, and line them.

The Northwest Regulars #6

During the early morning of July 10 while the Entiat IHC crew was fighting the Thirtymile Fire, the Northwest Regulars #6 (NWR#6), a Type 2 fire crew, was called up. The NWR #6 crew was made up of 21 individuals from two different Ranger Districts located in central Washington State. These were:

- the recently combined Lake Wenatchee and Leavenworth Districts(referred to as Lake Leavenworth)
- the Naches District

Eleven members of the NWR #6 crew were from Lake Leavenworth and ten were from Naches.

The crewmembers were contacted beginning just after midnight. They were to assemble in Leavenworth, Washington, and then drive to the Twisp Ranger Station for their briefing. They were informed they were being assigned to support the Libby South Fire. The majority of the crew had as little as one or two hours of sleep before being called.

When the Lake Leavenworth and Naches members of the NWR #6 crew met in Leavenworth around 3:00 a. m. they were organized into three squads. One squad consisted entirely of personnel from the Naches District. The other two squads were made up of people from both ranger districts. Not all crewmembers knew the individuals from the other district with whom they would be working.

At 7:00 a. m. , after about a three-hour drive from Leavenworth, the crew arrived at the Twisp Ranger Station to await their briefing. The NWR #6 crew was informed that they would not be going to the Libby South Fire. Rather, they would be assigned to do mop up on the smaller Thirtymile Fire. Many of the rookie crewmembers were disappointed. Pete Soderquist and Elton Thomas, the District FMO and Forest FMO, respectively, accompanied the NWR #6 crew to the fire. The group arrived at the fire site just after 9:00 a. m.

The Entiat IHC Actions During the Night

The Entiat IHC began their actions to line the spots around 1:30 a. m. Within twenty minutes Marshall Brown, the IHC Superintendent, reported that they had completed a fireline from the road to the river.

By 2:15 a. m., after containing two spots in the mostly “dog-haired” thicket, they moved across the river. Eventually they found a crossing log to allow easy access to the east side of the river. At that time, Okanogan Dispatch requested information on their resource needs for the morning. The Entiat IHC Superintendent, Marshall Brown, ordered a crew and an aircraft for the morning. He also ordered two Mark III pumps with kits, 1,500 feet of hose, 10 wyes, 10 nozzles, and 10 reducers. Confirmation was received three hours later at 5:26 a. m. that a Type III helicopter (Helicopter 13N) with a bucket and long line would be dispatched for arrival at 10:00 a. m. at the North Cascade Smokejumper Base (NCSB), located about 35 miles south of the fire site.

By 5:30 a. m. there were seven spots on the east side of the river covering about five to six acres. Two spots were estimated to be about one acre each.

The Entiat IHC took a break between about 5:30 a. m. and 6:30 a. m. to eat and rest. After the break they continued to work on the east side of the river digging a containment line and surrounding the spots until the NWR #6 crew relieved them. When they returned to the east side after 6:00 a. m. they noted that the “fire intensity had died down a lot.”

Transition to NWR #6

On the morning of July 10th, nearly all personnel on the Thirtymile Fire were suffering some effects of mental fatigue due to lack of sleep. This includes the Entiat IHC, the NWR #6, and key District and Forest personnel. As the day progressed, these effects would worsen, and provide one potential explanation for loss of situational awareness, compromised vigilance and decision-making.

When the NWR #6 crew arrived at the fire at 9:04 a. m. , the NWR #6 Crew Boss Trainer and Trainee met with the Entiat IHC Superintendent, Marshall Brown, to review the situation. Pete Soderquist, the District FMO, and Elton Thomas, the Forest FMO, also participated in this situation review meeting. This review meeting lasted about 45 minutes.

At that time the Entiat IHC provided the NWR #6 with a GPS map of the hot spots and the Entiat IHC's containment activities.

Ellreese Daniels and Pete Kampen, the NWR #6 Crew Boss Trainer and Crew Boss Trainee, respectively, were shown the hot spots by Kyle Cannon, the Entiat IHC Assistant Superintendent. It was determined that the highest priority was spots 3 and 4 on the east side of the river. The tactics were to get the pumps going early and get water on the fire, cool it down, and have the crew mop it up.

The Forest FMO estimated that although there was a lot of fire, it only covered about three acres scattered over a five acre area with very benign fire behavior. He and the District FMO discussed and checked on the availability of two other IHC crews. If they were available the plan was to have them assigned to the fire to knock it down and get it over quickly. The District FMO requested that a barricade be placed on the road to prevent unauthorized personnel from entering the area. Although approved by the District Ranger for the Methow Valley, the barrier was not put up until 3:17 p. m. that afternoon.

No Spot Fire Weather Forecast was issued for the Thirtymile Fire. Pete Soderquist provided a weather forecast based on a Spot Fire Weather Forecast for 6:00 p. m. the previous evening (July 9) for the Libby South Fire. This Libby South Fire forecast indicated low relative humidity, high temperatures and that the "fuel type was a trigger for fire behavior."

The Forest FMO reminded Pete Kampen, the NWR #6 Crew Boss Trainee, to use the Safety Briefing Card to brief the crew. Pete Kampen briefed the three squads using the Libby South Fire forecast information on the low humidity, high temperature, and a predicted wind event greater than 10 mph. He explained that the tactics would involve using hose lays to bring water from the river and digging hand lines around the hot spots. The briefing took about half an hour and was completed about 10:30 a. m. The NWR #6 crew was informed that this was a lot of work for them and that another 20-person crew was staged at Tonasket, Washington. (Later in the day Air Attack found out that this crew would arrive about 8:00 p. m.). During the discussion with the District FMO, Pete Kampen and Ellreese Daniels had been informed that the NWR #6 could expect support from Helicopter 13N for bucket work. The District FMO reminded them again just prior to departing for a Libby South Fire planning meeting.

The NWR #6 crew had eight handheld radios. When Pete Kampen attempted to call Okanogan Dispatch he could not make contact. Ellreese Daniels, the Crew Boss Trainer for the NWR #6, was able to contact Okanogan Dispatch using his handheld radio. This was in contrast to the Entiat IHC situation where they had to use their mobile radio in their truck to contact Okanogan Dispatch.

Pete Kampen and Ellreese Daniels agreed that Daniels would assume the role of the Incident Commander(IC) on the Thirtymile Fire and handle the communications. Kampen would manage the strategy and tactical decisions. Requests would be passed through Daniels to Okanogan Dispatch.

At 11:00 a. m. the Entiat IHC left the fire site and drove about two miles downriver to bed down at a campground. Twenty minutes later Pete Soderquist and Elton Thomas departed for the Libby South Fire ICP.

After the NWR #6 crew completed the safety briefings, the pumps were set up and the crew crossed the log to the east side of the river and began to apply water to the fire and dig line at about 11:00 a. m.

By about noon the crew experienced several equipment-related problems:

- They had difficulties keeping the two pumps running, possibly due to improper use of pressure relief valves, and lack of experience with pumps and hoses.
- Several hoses burst. Some felt that the hoses were old and the pump was "picky."
- At least four Pulaskis broke during operations on the east side of the river. One handle split and heads came off of the handles on three apparently new pulaskis.

The Crew Boss Trainee, Pete Kampen, decided to change tactics and dig a line to pinch the head of the fire. Jodie Tate, who had been operating the pumps was pulled off to dig lines. The fireline construction was difficult with a lot of roots. Some crewmembers realized they were digging line ahead of the fire and knew it was a "watch-out" situation.

At 12:08 p.m. Pete Kampen requested that Helicopter 13N be launched. Twenty minutes later he requested additional crews from Okanogan Dispatch. Twenty minutes later he requested additional crews from Okanogan Dispatch. Daniels considered it unusual for green foliage to be burning as it was for this time of year. Donica Watson had been posted as a lookout on the rock screen above the crew on the east side of the river. She was responsible for taking weather observations and relaying information to Ellreese Daniels. As the fire behavior began to intensify, Daniels removed her from the rock screen sometime after 2:00 p.m. because of poor access to the escape route. She was reassigned back to her squad. At this time Air Attack became the lookout for the Thirtymile Fire.

In response to the request for additional crews, the Okanogan Dispatch had attempted to contact the Entiat IHC. Since the Entiat IHC had not been contacted by 1:00 p.m., Pete Kampen sent one of the NWR #6 crewmembers to wake the Entiat IHC. The Entiat IHC Superintendent felt that the crew required more sleep and did not wake them until around 1:30 p.m. The Entiat IHC returned to the fire around 2:00 p.m. The NWR #6 crewmembers were working on the east side of the river at that time. The Entiat IHC Superintendent contacted Pete Kampen to review the situation. A little later Kampen decided to pull the NWR #6 crew back across the river to the road. The fire had been burning through the hoses in several places and spotting over their containment line. Pete Kampen accepted the fact that they "had lost the fire." At 3:00 p.m. the NWR #6 crew was pulled back to the lunch site “safety zone” on the west side of the river. There they joined the Entiat IHC crew and ate lunch, rested, watered, and sharpened their tools.

The Air Support Actions

Several times during the morning briefing the District FMO had informed the NWR #6 crew boss trainee and trainer that Helicopter 13N would be available for bucket work. Around 12:00 p.m. the NWR #6 was notified by the Okanogan Dispatch that Helicopter 13N was available 5 miles south of Winthrop at the North Cascade Smokejumper Base (NCSB). At 12:08 Pete Kampen (through Ellreese Daniels as his communications connection to Dispatch) requested that Helicopter 13N be launched with a bucket.

When contacted at 12:30 p.m. concerning the estimated time of arrival, the Okanogan Dispatch indicated that the helicopter required permission to dip out of the Chewuch River. (This area of the Chewuch River is a Research Natural Area, and the river is a habitat for endangered fish species).

Air Attack was diverted from the Libby South Fire to the Thirtymile Fire at 12:40 p.m. About twenty minutes later Air Attack stated that there was a dip site available down the river and another one was two miles up the canyon. Okanogan Dispatch repeated that they could not use the helicopter until they got permission. Permission was received at 2:00 p.m. to use the helicopter. (A detailed review of the sequence of events related to Helicopter 13N is presented in the Management Findings Section.)

Helicopter 13N departed for the fire at 2:38 p.m. from 8-Mile Camp which was about 20 miles south of the fire. Helicopter 13N began making water drops on small spots at the south edge of the fire and continued to work until having to refuel around 4:15 to 4:30 p.m. Before refueling, the fire had spread up the east canyon walls. After returning from refueling, the pilot of 13N noted that the fire spread had moved back to the canyon floor with spotting on the west wall of the canyon.

Air Attack ordered a single engine air tanker (SEAT) at 1:15 p.m. Around 1:40 p.m. Air Attack announced that the fire was getting active, growing, and additional crews and air support were needed soon. A few minutes after 2:00 p.m. the SEAT flew over the fire and decided the canyon was tight. Although he did not think it would be of much help, the SEAT pilot dropped the load on a small strip of timber. Air Attack decided to have the SEAT reload and hold.

At 2:34 p.m. Air Attack requested a heavy air tanker. About a half an hour later Tanker 62 was en route with an estimated arrival of 3:21 p.m. Also, at about 2 p.m., Ellreese Daniels ordered another tanker and a PBY. Tanker 12 was diverted from the Libby South Fire and arrived at the fire around 3:40 p.m. It could only make two drops before it was out of flight time. The PBY would have to stop at Omak Lake for water while en route to the fire.

Around 3:20 p.m., Air Attack reported that the fire had reached about 50 acres in size and was crowning and going to the ridge. Within 15 minutes the fire had grown to 100 acres and was almost on the ridge. Air Attack then requested two additional Type 1 or 2 tankers.

At 4:03 p.m. the First Butte Lookout reported that the Thirtymile Fire was forming its own thunderhead. By 4:18 p.m., Lead 66 requested the heavy tankers for the Libby South Fire. Both Air Attack and Lead 66 agreed that it looked like the Thirtymile Fire was going strong and it was moving in an uninhabited area. “It was not going to help throwing air tankers at it.” The tankers were diverted to the Libby South Fire. Helicopter 13N remained over the Thirtymile Fire dropping water.

Engines #701 & #704

At 2:27 p.m. Air Attack requested two engines. Engines #701 and #704 were then dispatched to the fire. Initially Engine #701 had been assigned to work helispot, dust abatement, air crash rescue, and helicopter management at 8-Mile Camp 20 miles downriver from the fire. According to Harry Dunn, the Supervisor on Engine #701, his mission from Okanogan Dispatch was to keep spots from the west side of the road.

Engine #704 (a 4x4 pickup with a slip-on pumper) had been directed by the Duty Officer to put a “road closed” sign approximately one mile in from the end of the pavement on the Chewuch road. The sign was put up at 3:17 p.m. En route to putting up the sign Engine #704 was contacted by Okanogan Dispatch and requested to report to the Thirtymile Fire.

The Supervisor of Engine #701 informed Engine #704 and three firefighters in a chase vehicle that their assignment was to keep the fire east of the road as per dispatch directions. Around 3:30 p.m. both Engines #701 and #704 arrived on the fire scene. Neither checked in with the IC nor received a tactical briefing.

Engines #701 and #704 drove past the Entiat IHC and NWR #6 crews and up the road to attack spots. Engines #701 drove almost to the end of the road and then headed back down looking for spots. The plan was to have Engine #701 work the north section and Engine #704 work the south section. The spots near the road were thought to be "rather small at this time."

Investigation – Equipment Findings

Significant Equipment Findings

In spite of the ready availability of water, relatively little water was applied to the fire during the initial attack phase. This was largely due to operational problems with pumps and hoses, as well as delays in availability of a Type III helicopter.

Prior to Entrapment

1. Water handling resources were made available to the Entiat IHC at about 1 a.m. on July 10th but the IHC Supervisor released the following equipment and personnel:
   - Engine #704 (slip-on pumper on a 4wd pickup) and 3-person crew
   - Chase truck and 3-person crew plus 2 other people
   - Mark III pump, wye gates, over 1,000 feet of hose

2. At 2:15 a.m. the Entiat IHC Superintendent requested water handling equipment and an aircraft for morning delivery -- two Mark III pumps, 1,500 feet of 1½-inch hose, 800 feet of 1-inch hose, 10 wyes, 10 nozzles, and 10 reducers.

3. The water handling equipment arrived with the NWR #6 crew at 9:04 a.m., and was put in use at around 11 a.m. when the NWR #6 began work.

4. The delivery of water for NWR #6 fire suppression activities was ineffective because of an inability to keep the pumps running continuously.
   - The hose layout (e.g., arrangement, size of hoses, and pressure reducers) was not conducive to optimal water operations, and limited the amount of water that the crew applied to the fire
   - At least three lengths of 1-inch hose were blown.
   - The pumps were not in continuous operation due to mechanical and/or operator problems.

5. The lack of a reliable and consistent water supply operation in conjunction with escalating fire behavior led to a decision to change the tactics from water suppression to direct hand line construction.

6. At least four pulaskis broke during operations on east side of the river. One handle split. The heads came off of three apparently new pulaskis.
7. Aviation resources were continuously over the fire from about 1:00 p.m. and there were no reported equipment malfunctions on any of the aircraft.

8. No vehicle problems were reported throughout the incident

9. The following aviation resources were assigned mid to late afternoon on July 10th:
   - One Type III helicopter
   - One SEAT (single engine air tanker)
   - Two Type I Air tankers
   - One Type II Air tanker (PBY)
   - One Air Attack
   - One Lead plane

10. The NWR #6 crew had eight handheld radios. There were minor problems with some handheld radios, however there was adequate communications capability with incident personnel, assigned aircraft, and dispatch.

11. The Okanogan Forest Dispatch radio system tape recorder was not operational; therefore there are no voice-recorded tapes for July 9th and 10th.

Note: Please see full report for information on The Entrapment, The Deployment Area, Deployment, The Rescue and Evacuation, References, Investigation Findings, Environment Findings, Equipment Findings, People Findings, Management Findings, Standard Fire Orders, Watch Out Situations, Epilogue, The Investigation Team, Incident Time Line, and Appendices. These sections are not included here; except one part of the investigation findings related to equipment is presented.

UNIT OVERVIEW

Course Portable Pumps and Water Use, S-211

Unit 2 – Equipment

Time 1–2 Hours

Objectives

1. Distinguish the differences between the two cycle and four cycle engines and identify which one of these differences is most important to a pump operator.
2. Label the parts of a commonly used portable pump.
3. Identify the purpose of a suction hose and a discharge hose.
4. Match types of wildland fire appliances and tools with their respective purpose.
5. Identify nozzle types.
6. List one type of national portable pump kit.

Strategy

This unit introduces students to the types of equipment used in portable water delivery systems – pumps, hoses, appliances, and nozzles. Students will learn how to operate the equipment in Unit 3 (Responsibilities) and Unit 5 (Field Exercise).

Instructional Methods

- Informal lecture and discussion with PowerPoint.
- This PowerPoint presentation contains several animations. Review these animations before presentation.
- Slide 2-15 is an interactive animation of a portable pump. Instructions on opening the pump animation are written on the slide. Instructions on how to manipulate the pump animation are written in the popup window. Practice using the interactive animation of a portable pump before presentation.

Instructional Aids

- ☐ Computer with LCD projector, presentation software, and screen
- ☐ Incident Response Pocket Guide (IRPG)
- ☐ Examples of hoses (suction and discharge), appliances, hose accessories and tools, nozzles, and sprinklers discussed in this section
- ☐ High Pressure Portable Pump Kit
- ☐ Laser pointer

Exercise

- None

Evaluation Methods

- Oral review session at end of the unit.
- Objectives will be tested in Final Exam (written).

Outline

Write the unit outline on flip chart paper. This unit contains a lot of information; therefore, it is important to write more of the unit outline. Refer to the outline as appropriate to help students stay on track. The outline should look like this:

I. Portable Water Pumps

  A. How Pumps Work – Engine and Pump Head

  B. Parts of a High Pressure Pump

  C. Types of Portable Pumps

II. Hoses

  A. Suction (Intake) Hoses

  B. Discharge Hoses

III. Appliances, Accessories and Tools for Hose Lays

A. Appliances

B. Hose Accessories and Tools

IV. Nozzles and Sprinklers

A. Twin Tip Nozzle (Forester)

B. Adjustable Barrel Nozzle (KK and Lexan)

C. Adjustable Barrel Nozzle – Garden Hose Nozzle (3/4 inch)

D. Sprinklers

V. Kits

A. National Kits

B. Local Geographic Kits

VI. Review

Aids and Cues Codes

The codes in the Aids and Cues column are defined as follows:

IG – Instructor Guide	IR – Instructor Reference
SW – Student Workbook	SR – Student Reference
HO – Handout	Slide – PowerPoint

UNIT PRESENTATION

Course: Portable Pumps and Water Use, S-211

Unit: 2 – Equipment

OUTLINE	AIDS & CUES
Unit Title Slide.	Slide 2-1
Click on audio icon to hear firefighter story about pumps.	Slide 2-2
Present Unit Objectives.	Slide 2-3 Slide 2-4
Refer students to unit outline on flip chart; review main headings so students can see big picture and stay on track.	
I. PORTABLE WATER PUMPS	Slide 2-5
This section discusses how pumps work, types of pumps, and parts of a pump.	
A. How Pumps Work – Engine and Pump Head	Slide 2-6
Having a basic understanding of how pumps work can make or break a pump operator; it will help a pump operator start the pump, keep it running, and troubleshoot in the field.	
A pump is made up of two parts: an engine (power source) and a pump head.	

OUTLINE	AIDS & CUES
1. Types of engines	
• Two cycle engines	Slide 2-7

Click on slide image to view animation. Use laser pointer to highlight features.

With a two cycle or two stroke engine, the mixed gas (unleaded gas and oil) is ignited every time the piston reaches the top of the cylinder, and exhaust is evacuated when the piston reaches the bottom of the cylinder. This completes the two cycles the piston makes.

On initial startup there is no mixed gas in the cylinder for the spark plug to ignite.

When the operator pulls the starter cord, the piston is engaged and draws the mixed gas from the carburetor into the crank case to initiate the firing sequence.

While the engine is running, the piston’s upward stoke compresses the mixed gas in the top portion of the cylinder, preparing it to be ignited by the spark plug.

At the same time as there is compression above the piston, a vacuum is created in the crankcase underneath the piston. This vacuum draws the mixed gas into the crankcase.

OUTLINE	AIDS & CUES
The two cycles include: – Compression (ignition) The power generated from the combustion of the previous power stroke provides enough momentum in the engine for the piston to rise, covering both the intake and exhaust ports, and compresses the mixed gas, preparing it for combustion by the spark plug. – Transfer (exhaust) As the piston begins its down stroke from the force of the combusting mixed gas, the expanding heated exhaust escapes out through the muffler. A valve in the crankcase prevents backflow of the mixed gas/air mixture into the carburetor. As the piston reaches the bottom of its cycle, the intake port is exposed, allowing the compressed the mixed gas/air mixture in the crankcase to travel into the top of the cylinder.	

OUTLINE	AIDS & CUES
At this point, both the exhaust port and intake port are momentarily exposed at the same time.	
This is when some mixed gas escapes out through the exhaust port unburned.	
• Four cycle engines	Slide 2-8
In a four cycle or four stroke engine, the piston has to raise and lower twice to complete the cycle of igniting fuel inside a cylinder; the piston makes four cycles.	
Click on slide image to view animation. Use laser pointer to highlight features.	
– Fuel intake (down)	
During the intake of fuel, the piston moves downward, creating a vacuum and drawing fuel/air mixture from the carburetor through the intake valve into the cylinder.	
As the piston reaches the bottom of its first stroke, the intake valve is closed and the piston begins the second phase of the cycle.	

OUTLINE	AIDS & CUES
– Compression of fuel (up) The momentum from the previous ignition sequence forces the piston to rise, compressing the fuel/air mixture in the cylinder. As the piston reaches the top of its stroke, the spark plug ignites, causing rapid combustion and expansion of the fuel/air mixture thus forcing the piston downward. – Power generation from firing (down) The forcing downward of the piston is described as horse power generated for external use of the engine to do such things as making a car move forward or spinning the blade on a lawn mower. A small amount of this energy is used in the form of inertia to drive the piston upward once more. – Discharge of exhaust (up) As the piston begins the fourth and final stroke in the series, an exhaust valve is opened.	

OUTLINE	AIDS & CUES

With this valve open, the piston climbs once more and forces the burned exhaust out of the cylinder through the muffler.

Ask students:

- **What type of engine does a weed eater have?**

  Answer: 2 cycle

- **What type of engine does an automobile have?**

  Answer: 4 cycle

- **What type of engine does a portable pump have?**

  Answer: 2 cycle

- **What type of engine does a heavy duty pump have?**

  Answer: 2 cycle

OUTLINE	AIDS & CUES
• What are some other differences between a two cycle and a four cycle engine?	Slide 2-9

Factor	Two Cycle Engine	Four Cycle Engine
Lubrication (very important)	Oil is mixed with the gas; engine runs on two cycle oil mixed with unleaded gasoline.	Has a separate oil reserve and lubrication system; runs on unleaded gasoline (gas is NOT mixed with oil).
Weight	Typically lighter weight.	Typically heavier weight.
Fuel efficiency and exhaust emissions	Typically less fuel efficient and produces more exhaust emissions.	Typically more fuel efficient and produces less exhaust emissions.
Orientation	Can operate in any vertical orientation.	Can only operate on relatively level surfaces due to the location of the oil reservoir and the need for the engine to draw oil from this reservoir to the top of the engine.

For pump operators, the most important difference between a two cycle and a four cycle engine is the way the motor is lubricated.

The pump operator needs to know this to ensure the pump's engine is receiving its lubrication from the proper source, whether it is the oil reservoir or mixed with the gas, to prevent damaging the engine and making the pump inoperable.

OUTLINE	AIDS & CUES
Discuss possible consequences if a pump becomes inoperable in the field. For example, the tactical objective is not going to be accomplished.	
2. Carburetor	Slide 2-10
Go slow and make sure students understand how the carburetor works.	
The carburetor premixes vaporized fuel and air in proper proportions and supplies the mixture to the engine. If there is too much fuel mixed with air, the engine will either not run at all (flooded) or run poorly (smokes, stalls easily). If there is not enough fuel mixed with air, the engine will not run, and it could be damaged.	
The choke, throttle, and idle adjustment screws all play a role in how the carburetor works.	
It is important NOT TO ADJUST the low idle adjustment screw. With very little fuel entering the engine, there is very little oil entering as well. Poor adjustment of this low idle adjustment screw will cause severe engine damage.	
• **When starting a cold engine**, a very rich mixture of fuel is needed.	Slide 2-11
Click on image to play animation. Use laser pointer to help explain concepts.	

OUTLINE	AIDS & CUES
The choke lever is in the "start" position; the choke is closed, which draws more fuel than air through the high idle adjustment screw.	
The throttle lever is in the "start" position; this opens the throttle to allow the fuel-rich mixture into the engine for the initial "cough" or "pop" of ignition.	
Ask students: What would happen to the pump if the pump operator kept trying to start the pump with the choke closed and the throttle open? **Answer: Flood the engine; because the engine is getting too much fuel and not enough air.**	
• **When the engine is idling**, less fuel and air is needed to keep the engine running (compared to starting).	Slide 2-12
Click on image to play animation. Use laser pointer to help explain concepts.	
The choke lever is in the "run" position; the choke is open.	
The throttle lever is in the start-warm-up position.	
The negative pressure created by the piston movement inside the cylinder is now drawing a minimal amount of fuel and air to keep the engine running.	

OUTLINE	AIDS & CUES
• **When the engine is running at full throttle (maximum power)**, the maximum amount of fuel and air is needed.	Slide 2-13

Click on slide image to view animation. Use laser pointer to highlight features.

The choke lever is on “run”; choke shutter is open.

The throttle lever is on “full throttle”; throttle is open.

At the high idle adjustment screw, liquid fuel is vaporized and mixes with the air to create the optimum firing mixture.

At higher altitudes, the high idle adjustment screw may need to be adjusted to maximize pump performance (since oxygen in the ambient air varies with altitude). Improperly adjusting the high idle adjustment screw will diminish the pump’s performance.

3. Pump head (centrifugal)	Slide 2-14

Click on slide image to view animation. Use laser pointer to highlight features.

There are different types of pump heads, but we are focusing on the centrifugal pump head. The pump operator needs to know:

- How the water comes into the system

OUTLINE	AIDS & CUES
• How the water gains speed and velocity	
• How the water exits the system	
B. Parts of a High Pressure Pump	Slide 2-15
This section focuses on the parts of a high pressure portable pump. It is important to first become familiar with the parts of the pump, then in Unit 3 (Responsibilities) you will learn how to start, operate, maintain, and troubleshoot the pump.	
Materials needed: High pressure pump **Follow instructions on slide to open interactive image of the portable pump and show the parts of the pump.** **As you show students the pump parts using the interactive image, also point out parts on the "real" pump.**	
• Priming port	
• Suction inlet (intake port)	
• Pump head	
• Spark plug and spark plug wire	
• Muffler	
• Spark arrestor	
• Starter rewind	
• Carburetor (behind air filter)	
• Choke lever	

OUTLINE	AIDS & CUES
• Overspeed reset rod • On/off switch • Throttle lever • Air filter • Fuel supply hose connect • Pump release clamp • Grease fitting • Discharge port • Electronic ignition	
Newer pumps have an electronic ignition, but many pumps in the field still have the older points and condenser style ignition systems.	
C. Types of Portable Pumps	Slide 2-16
Discuss pumps used locally as appropriate.	
This section discusses three general types of pumps. For each type of pump, a general description, weight, type of fuel, and pump performance are provided.	
Pump performance is important because it helps determine whether the pump is capable of providing the desired flow (gpm) and pressure (psi) for the specific hose lay.	Slide 2-17
Refer to the Portable Pump Performance – National Cache Pumps table (HO 2-1) for **flow (gpm)** and **pressure (psi)** for the different types of pumps.	HO 2-1

OUTLINE	AIDS & CUES
The data in this table comes from the Water Handling Equipment Guide. Pump performance will be discussed in more detail in Unit 4 (System Design and Hydraulics).	
1. High Pressure pumps (e.g., Mark 3 Pump, Wick 375)	Slide 2-18

- High pressure pumps are the most widely used portable pumps. They provide more pressure and flow than lightweight pumps. They are used for a variety of tactical objectives such as initial attack, mop up, and structure protection.
- Pumps weigh 30 to 60 pounds. One person can carry the pump.
- Fuel
  - High pressure pumps (two cycle engines) typically use mixed gas; however, refer to manufacturer's recommendations.
  - Mark 3 pump fuel consumption is 1.2 gallons per hour.

OUTLINE	AIDS & CUES
• Pump performance	Slide 2-19
– Refer to the Portable Pump Performance – National Cache Pumps table (HO 2-1) and identify the pump performance (gpm and psi) for high pressure pumps.	HO 2-1
– The IRPG is another reference for Mark 3 pump performance data.	
Note: The pump performance values in the IRPG do not directly correspond with the values in the Portable Pump Performance – National Cache Pumps table (HO 2-1). Pump flows are normally given in 50 psi increments (refer to Portable Pump Performance – National Cache Pumps table [HO 2-1]), and the performance information in the IRPG is done in 10 gpm increments.	HO 2-1
– Pump performance will be discussed in more detail in Unit 4 (System Design and Hydraulics).	

OUTLINE	AIDS & CUES
2. Floatable pumps	Slide 2-20
	
• The floatable pump, which is similar to the high pressure portable pump except it floats and has no suction hose, is required. Floatable pumps are typically used on lakes (especially if there is a rocky, steep shoreline); they are also used in ditches and drop tanks.	
• This pump weighs more than 60 pounds.	
• Fuel Floatable pumps (typically two cycle engine) fuel requirements are variable; refer to manufacturer's recommendations.	
• Refer to the Portable Pump Performance – National Cache Pumps table (HO 2-1), and identify the pump performance (gpm and psi) for floatable pumps.	Slide 2-21 HO 2-1

OUTLINE	AIDS & CUES
3. Lightweight pumps (e.g., Honda WX10, Shindaiwa GP-45)	Slide 2-22

• This type of pump is typically used on light-duty initial attack.	
• This pump weighs less than 30 pounds.	
• Fuel requirements are variable for lightweight pumps (can be either two or four cycle engine); refer to manufacturer’s recommendations.	
• Refer to the Portable Pump Performance – National Cache Pumps table (HO 2-1), and identify the pump performance (gpm and psi) for lightweight pumps.	Slide 2-23 HO 2-1

OUTLINE	AIDS & CUES

II. HOSES

Slide 2-24

Materials needed: Suction hoses and discharge hoses

There are two types of hoses used in portable water delivery systems:

Slide 2-25

A. Suction (Intake) Hoses

Show students suction hoses.

Suction hoses are used to draft water; one end of the hose is connected to the suction inlet (intake port) on the pump, and the other end is placed in the water source.

Suction hoses are designed to handle vacuum and they are therefore, always rigid.

They are usually furnished in 8- and 10-foot lengths.

B. Discharge Hoses

Show students discharge hoses.

Discharge hoses carry water from the pump to the fire, portable tank, or other location; one end is connected to the discharge port of the pump. They are designed to handle pressure.

OUTLINE	AIDS & CUES
• The most common size of discharge hose used in wildland firefighting include: – ¾″, 1″, 1½″, and 2½″ diameters – 50- and 100-foot lengths • Material types (e.g., synthetic, woven fabric) • Thread types – National Pipe Straight Hose (NPSH) – National Hose (NH) – Garden hose thread (GHT) • Important to use gaskets.	
III. APPLIANCES, ACCESSORIES, AND TOOLS FOR HOSE LAYS	Slide 2-26
Materials needed: Examples of appliances, accessories, and tools discussed in this section. **As you discuss this section, show students the different types of appliances (fittings, valves, intakes), accessories, and tools.**	

OUTLINE	AIDS & CUES
A. Appliances	
1. Fittings	Slide 2-27

- Thread adapter: Connects two hoses of the same size but have different thread types.

- Reducer: Reduces from one size of hose to a smaller hose size.

- Increaser: Increases from one size to a larger size.

OUTLINE	AIDS & CUES
• Double female: Connects two male ends of hose or fittings.	Slide 2-28

• Double male: Connects two female ends.

OUTLINE	AIDS & CUES
• Plain wye: Used to divide one line into two.	Slide 2-29

• Siamese wye: Used to connect two lines into one.

OUTLINE	AIDS & CUES

2. Valves

Slide 2-30

- Gated wye valve: Used to divide one line into two.

- Siamese gated wye valve: Used to unite two lines into one.

OUTLINE	AIDS & CUES
• Hose line tee with valve	
	
Is placed on a 1½″ main line to branch or “T” off into a smaller 1″ lateral line. It may have a shutoff feature to control flow in a 1″ lateral.	
• Check and bleeder valve	Slide 2-31
	

OUTLINE	AIDS & CUES

The “check valve” helps maintain prime if the foot valve isn’t working correctly; it also keeps water from flowing back into the pump when the pump stops, and relieves pressure on the pump when it is restarted.

The “bleeder” keeps the pump from overheating if all discharge nozzles are shut off; the bleeder recirculates the water back to the water source.

- Pressure relief valve

A spring-loaded, adjustable valve placed between the pump and the discharge hose. Used to release excess pressure on the pump due to kinks or nozzle shutoff.

OUTLINE	AIDS & CUES
• Ball valve: Valve used to stop the flow of water.	Slide 2-32

3. Intake – Foot Valve/Strainer	Slide 2-33

OUTLINE	AIDS & CUES

Always use a foot valve/strainer to prevent damage to the pump.

Most foot valves are a foot valve and strainer assembly. It is spring loaded to prevent water from running out of the suction hose as it is being primed or if the pump is shut off.

The strainer is a wire or metal guard used to keep debris from clogging pumps. Due to environmental resource concerns, smaller screens may be needed.

B. Hose Accessories and Tools — Slide 2-34

1. Hose shutoff clamp

These clamps are used to temporarily shut off water for replacing or adding hose in a hose lay, or when changing nozzles.

OUTLINE	AIDS & CUES

When using a clamp on synthetic hose, use an "insert" as a "quick fix" so the hose clamp doesn't slip out of position. Refer to this website for more information:

www.fs.fed.us/eng/pubs/html/96511305/96511305.html

2. Spanner wrench

Used to loosen and tighten connections. Comes in many sizes and shapes.

3. Gravity sock

Gravity socks can be used instead of pumps when water is located at a higher elevation than the fire. The mouth of the sock is placed in the stream and anchored securely. The tail is attached to the fire hose.

OUTLINE	AIDS & CUES
IV. NOZZLES AND SPRINKLERS	Slide 2-35
Materials needed: Examples of nozzles and sprinklers **As you discuss this section, show students the different types of nozzles and sprinklers.**	
A. Twin Tip Nozzle (Forester)	Slide 2-36
Refer to Types of Nozzles (HO 2-2) and review the General Characteristics column for twin tip nozzles. The information in the Tactical Use column will be covered in Unit 3 (Responsibilities).	HO 2-2
B. Adjustable Barrel Nozzle (KK and Lexan)	Slide 2-37
Refer to Types of Nozzles (HO 2-2) and review the General Characteristics column for adjustable barrel nozzles. The information in the Tactical Use column will be covered in Unit 3 (Responsibilities).	HO 2-2
C. Adjustable Barrel Nozzle – Garden Hose Nozzle (3/4 inch)	Slide 2-38
• Refer to Types of Nozzles (HO 2-2) and review the General Characteristics column for adjustable barrel nozzle – garden hose nozzle. The information in the Tactical Use column will be covered in Unit 3 (Responsibilities).	HO 2-2

OUTLINE	AIDS & CUES
D. Sprinklers	
• Refer to Types of Nozzles (HO 2-2) and review the General Characteristics column for sprinklers. The information in the Tactical Use column will be covered in Unit 3 (Responsibilities).	HO 2-2
• Sprinkler kits are discussed in the next section.	
V. KITS	Slide 2-39
Kits contain most of the equipment and supplies needed for the water delivery system; however, they don't contain everything (e.g., fuel) and sometimes some supplies are missing.	
Purpose of this section is to inform students that kits are available; discuss the kits as appropriate for the audience. **Inspecting kit items is discussed in Unit 3 (Responsibilities).**	
A. National Kits	Slide 2-40
• High Pressure Portable Pump Kit	
• Lightweight Pump Kit	
• Mop Up Kit	Slide 2-41
• Sprinkler Kit	

OUTLINE	AIDS & CUES
B. Local Geographic Kits	Slide 2-42
Discuss local geographic kits.	
Local geographic areas have their own kits, and kit contents will vary by region.	
VI. REVIEW	Slide 2-43
Review key points in the unit with PowerPoint slides. Answer any questions students have.	
Question 1. In a two cycle engine, where is the oil located that lubricates the engine?	Slide 2-44
Answer: Oil is mixed with the gas.	
Question 2. In a four cycle engine, where is the oil located that lubricates the engine?	Slide 2-45
Answer: Oil is located in a separate oil reserve (crankcase).	
Question 3. Why is it important for the pump operator to know how the engine is lubricated?	Slide 2-46
Answer: To ensure the pump's engine is receiving its lubrication from the proper source, whether it be oil reservoir or mixed with the gas, to prevent damaging the engine and making the pump inoperable.	
Question 4. Does a two cycle engine typically produce more or less exhaust emissions than a four cycle engine?	Slide 2-47
Answer: More	

OUTLINE	AIDS & CUES
Question 5. The fire is in a remote location (no roads), and you need a pump that can provide a lot of pressure and flow? Which types of pumps would work best?	Slide 2-48

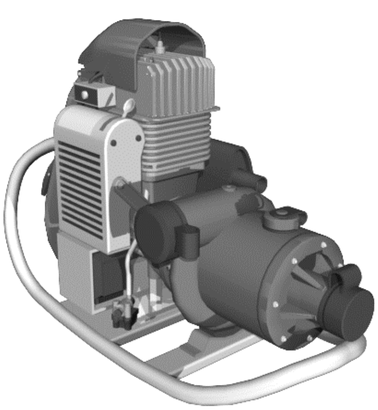
Answer:

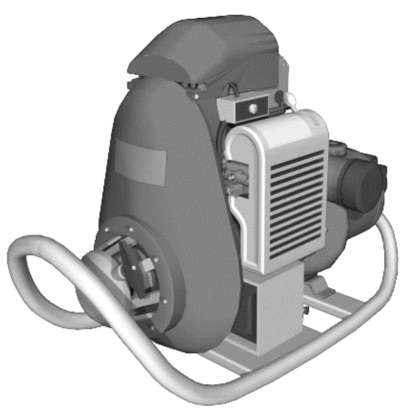
- **High pressure portable pump**
- **Floatable pump**
- **Lightweight portable pump**

Question 6. Identify these parts on the pump:	Slide 2-49

Click on slide image to view animation. Use laser pointer to point to the pump parts.

- Suction inlet (intake port)
- Priming port
- Discharge port
- Air filter
- Throttle lever
- Spark plug
- Muffler





OUTLINE	AIDS & CUES
Question 7. What is the purpose of a suction hose?	Slide 2-50
Answer: Draft water from the water source to the pump; designed to handle vacuum.	
Question 8. What is the purpose of a discharge hose?	Slide 2-51
Answer: Carry water from the pump to the fire, portable tank, or other location; designed to handle pressure.	
Question 9. One of the purposes of this appliance is to help maintain prime if foot valve isn't working correctly. What is the appliance?	Slide 2-52
Answer: Check and bleeder valve	
Question 10. The purpose of this appliance is to divide one line into two. What is the appliance? 	Slide 2-53
Answer: Gated wye valve	

OUTLINE	AIDS & CUES
Question 11. What types of nozzles are these?	Slide 2-54

Answer: Twin tip

Answer: Adjustable barrel

OUTLINE	AIDS & CUES
Question 12. There are several pump and pump-related kits that can be ordered from the national cache. What are the names of those kits? **Answer:** • **High Pressure Portable Pump Kit** • **Lightweight Pump Kit** • **Mop Up Kit** • **Sprinkler Kit**	Slide 2-55
Review Unit Objectives.	Slide 2-56 Slide 2-57

UNIT OVERVIEW

Course Portable Pumps and Water Use, S-211

Unit 3 – Responsibilities

Time 2–3 Hours

Objectives

1. Given scenarios and photos, identify risk management, fuel handing, and environmental concerns.
2. Identify methods to prevent cavitation and water hammer.
3. List the four components that should be included in the design of a portable water delivery system.
4. Given photos, critique a portable pump setup.
5. Identify how to prevent the engine from flooding when starting the pump.
6. Identify how to troubleshoot common problems with portable pumps.
7. Identify how to select nozzles and apply water to achieve tactical objectives.
8. List general guidelines for maintaining and retrieving hoses.

Strategy

This unit addresses the various responsibilities (e.g., risk management, design, portable pump, nozzle) associated with operating a portable water delivery system. In Unit 5 (Field Exercise) instructors will demonstrate the responsibilities and students will practice them.

Instructional Methods

- Informal lecture and discussion with PowerPoint
- Exercise

Instructional Aids

- ☐ Computer with LCD projector, presentation software, and screen
- ☐ Flip chart and markers
- ☐ Incident Response Pocket Guide (IRPG)
- ☐ Interagency Transportation Guide for Gasoline, Mixed Gas, Drip-Torch Fuel, and Diesel (online at www.nwcg.gov/pms/pubs/442/pms442.pdf)
- ☐ High Pressure Portable Pump Instructions (1 per student)

Exercise

- Pump Accident Investigation Report

Evaluation Methods

- Oral review session at end of the Unit.
- Objectives will be tested in Final Exam (written).

Outline

Write the unit outline on flip chart paper. The outline should look like this:

I. General Responsibilities

II. Design Responsibilities

III. Portable Pump Responsibilities

IV. Nozzle Responsibilities

V. Hose Lay Responsibilities

VI. Setting Up Multiple Pump Systems

VII. Chemicals (Optional)

VIII. Review

Aids and Cues Codes

The codes in the Aids and Cues column are defined as follows:

IG – Instructor Guide	IR – Instructor Reference
SW – Student Workbook	SR – Student Reference
HO – Handout	Slide – PowerPoint

UNIT PRESENTATION

Course: Portable Pumps and Water Use, S-211

Unit: 3 – Responsibilities

OUTLINE	AIDS & CUES
Unit Title Slide.	Slide 3-1
Click on audio icon to hear firefighter story about pumps.	Slide 3-2
Present Unit Objectives.	Slide 3-3 Slide 3-4
Refer students to unit outline on flip chart; review main headings so students can see big picture and stay on track.	
I. GENERAL RESPONSIBILITIES	Slide 3-5
This section discusses <u>general</u> responsibilities related to portable water delivery systems: risk management, environmental concerns, and communication.	
A. Risk Management	Slide 3-6
1. Always wear appropriate Personal Protective Equipment (PPE); keep sleeves down.	
• The pump operator is required to wear eye and hand protection during fueling operations, and ear protection is needed when operating the pump.	

OUTLINE	AIDS & CUES
• The nozzle operator needs to wear eye protection to prevent backsplash of hot or burning debris in the eyes.	
2. Ensure LCES is established and known.	Slide 3-7
• The pump operator needs to maintain good situational awareness at all times and ensure good communications methods are in place.	
• The nozzle operator is at high risk due to proximity to fire.	
3. When handling fuel, follow additional safety precautions:	Slide 3-8
• Do not operate a radio or any other portable electronic device such as a cell phone while engaged in fueling operations.	
• Refer to the publication below for fuel handling and transportation information.	
It is important for students to know there is a publication that addresses transportation and fuel handling.	
Interagency Transportation Guide for Gasoline, Mixed Gas, Drip-Torch Fuel, and Diesel (online at www.nwcg.gov/pms/pubs/442/pms442.pdf)	

OUTLINE	AIDS & CUES
4. Follow first aid guidelines in IRPG.	Slide 3-9
Refer students to first aid guidelines in IRPG.	
B. Environmental Concerns	Slide 3-10
Follow the directions given by your supervisor, Resource Advisor, or Agency Administrator regarding environmental concerns.	
Examples of environmental concerns include:	
• Fuel spill; notify supervisor or resource advisor.	
• Species considerations:	
– Sensitive species	
– Invasive species (e.g., aquatic)	
– Threatened and endangered species	
• Minimize impact to site	
– Keep area clean (dispose of garbage)	
– Secure loose items (from wind)	
• Rehabilitate site	
C. Communication	Slide 3-11
1. Communication among the supervisor, pump operators, nozzle operators, and other fireline personnel is critical for safety and to meet tactical objectives.	
• Supervisor needs to stay in close communication with pump operator and nozzle operator.	

OUTLINE	AIDS & CUES
• Pump operator communicates with: – Nozzle operator when starting and shutting down the pump, and when troubleshooting. – Supervisor if there is an environmental concern (e.g., fuel spill), if there are equipment problems, or if more equipment is needed. – Other fireline personnel to coordinate operations or troubleshoot the system.	
• Nozzle operator communicates with: – Pump operator when there are problems with water discharging out of the system (i.e., not enough water or pressure). – Pump operator and other nozzle operators about number of nozzles that can be opened simultaneously. – Other fireline personnel to coordinate operations or troubleshoot the system.	
2. Communication methods	Slide 3-12
Radio and hand signals are the typical forms of communication. Hand signals are typically used when the pump is running.	

OUTLINE	AIDS & CUES
Refer students to IRPG – Water Use Hand Signals.	
D. Prevent Cavitation and Water Hammer	
1. Cavitation	Slide 3-13
Cavitation occurs when cavities or bubbles form in the water in the low pressure (suction side) of the pump, causing deep pits in the surface of the impeller. When cavitation occurs, it reduces the pump's efficiency and can cause significant damage. Cavitation can occur rapidly.	
Cavitation is <u>not</u> a loss of prime.	
Common causes of cavitation include:	Slide 3-14
• Restricted water flow (clogged strainer or defective check valve)	
• Air entering suction hose (water whirl, hole in suction hose, loose coupling)	
• Suction hose diameter too big or too small.	
• Downhill hose lay with extreme water demand	
• High-altitude pumping	

OUTLINE	AIDS & CUES
What are symptoms that cavitation is occurring?	
Answer: • **Pump has increased engine revolutions per minute (rpm) with no increase in pump output; getting hotter; making a lot more noise; and/or vibrating more.** • **Quivering or collapsed hose.**	
To prevent cavitation: • Keep strainer clean and free of debris. • Locate pump as close to water source as practical. • Ensure adequate water supply. • Ensure diameter of suction hose is accurate.	Slide 3-15
2. Water hammer	Slide 3-16
In a delivery system, water hammer occurs when flowing water is suddenly stopped, resulting in shock waves traveling back the length of hose at high speeds, producing rapid vibrations. The more water that is flowing through the hose, the more danger there is and the greater the potential for injury to the nozzle operator.	
The most common causes of water hammer are when a valve is closed suddenly at an end of a line; or vehicles driving over hose.	Slide 3-17

OUTLINE	AIDS & CUES
What are symptoms that water hammer is occurring or has occurred?	
Answer: • **Pressure wave through the hose.** • **Broken hoses and valves.** • **Pump stops.**	
What can a pump or nozzle operator do to prevent water hammer? • Slowly close valves and nozzles. • Keep nozzles slightly cracked open at all times. • Protect hoses from being driven over.	Slide 3-18
We have just covered general responsibilities related to portable water delivery systems. Now it is time to do an exercise.	

OUTLINE	AIDS & CUES
EXERCISE: Pump Accident Investigation Report	Slide 3-19
Purpose: Students will read the State of Alaska Accident Investigation Factual Report and discuss.	
Time: 30 minutes	
Format: Students read report individually; large group discussion.	
Materials needed: State of Alaska Accident Investigation Factual Report	IR 3-1
Instructions:	
1. Refer students to the exercise (SW page 3.9).	SR 3-1
2. Direct students to read the report and answer the questions.	
Question 1. What task was the Idaho City crew assigned on July 9?	
Answer: Develop a water supply using Mark 3 pumps, folda-tanks, and a hose lay to supply water to assist with suppression of fire.	
Question 2. A member of the Idaho City crew was assigned to be the pump operator. What task was assigned?	
Answer: Deploying the #2 pump in the water supply operation.	
Question 3. Briefly outline how the accident happened.	
Answer:	
• **Pump Operator (PO) checked pump and fuel level.**	

OUTLINE	AIDS & CUES

- **PO reduced the rpms of the pump.**
- **PO removed bung from jerry can (pump was still running).**
- **Vapors and liquid escaped, came in contact with hot muffler and engine components of pump, and ignited the vapors.**

Question 4. What were the three causal factors and findings identified in the report?

Answer:

- **Placement of jerry can in close proximity to Mark 3 muffler and in an angled alignment with the exhaust.**
- **Size and shape of fuel containment dyke may have been a contributing factor in the placement of the jerry can next to the muffler.**
- **Briefing Idaho City hotshot crew received regarding very strict spill prevention and reporting may have been interpreted to include all incidents.**

Question 5. What did you learn from reading this report?

Any answer is correct.

3. Facilitate a large group discussion on questions and answers.

End of Exercise.

OUTLINE	AIDS & CUES
II. DESIGN RESPONSIBILITIES	Slide 3-20
Typically the squad boss or crew boss has overall responsibility for designing portable water delivery systems, especially more complicated delivery systems. However, an experienced pump operator will often design simpler systems.	
A. Mental Image and Design Schematic	Slide 3-21
For simpler delivery systems, a mental image of the design is all that is needed.	
However, as delivery systems get more complicated, it is essential to plan ahead and develop a schematic on paper to ensure the delivery system will work efficiently and effectively.	Slide 3-22
How to draw this schematic will be covered in Unit 4 (System Design and Hydraulics).	
B. Designing the Delivery System	Slide 3-23
When designing the delivery system, remember to consider the tactical objectives, resources (personnel and equipment), and site characteristics.	
Incorporate these components into the design.	
• Portable pump configurations	Slide 3-24
Distribute copies of Portable Pump Configurations.	HO 3-1
Review Portable Pump Configurations.	

OUTLINE	AIDS & CUES
• The information on pressure, flow, and friction loss will be discussed in Unit 4 (System Design and Hydraulics).	
• Hose lay design	Slide 3-25
Distribute copies of Types of Hose Lays.	HO 3-2
Review Types of Hose Lays.	
The information on pressure, flow, and friction loss will be discussed in Unit 4 (System Design and Hydraulics).	
Ask students: What hose lay sets up quickly? • **Answer: Simple hose lay** **Ask students: What hose lay would you use if it is a hot, fast-running fire?** • **Answer: Progressive hose lay**	
• Nozzle type(s)	Slide 3-26
Refer to Types of Nozzles (HO 2-2), which was already discussed in Unit 2 (Equipment).	Previous HO 2-2
• Hydraulic calculations, as appropriate	Slide 3-27
Remember, the system needs to be hydraulically feasible – it needs to work. Include the hydraulic calculations on the schematic, as appropriate.	
Hydraulic calculations will be discussed in Unit 4 (System Design and Hydraulics).	

OUTLINE	AIDS & CUES
III. PORTABLE PUMP RESPONSIBILITIES	Slide 3-28
This section discusses the responsibilities related to operating portable pumps.	
Some pumps have a reputation of being difficult to operate, but in many situations the problems with the pump could have been prevented by the pump operator. Getting as much experience as you can is essential to becoming a good pump operator.	
There are some excellent references to use in the field when working with portable pumps.	
• High Pressure Portable Pump Instructions (comes in the kit)	Slide 3-29
Distribute copies of High Pressure Portable Pump Instructions and review the headings. Do not go into detail.	HO 3-3
• IRPG – Mark 3 Pump Information	Slide 3-30
Refer students to appropriate pages in IRPG and briefly review the headings so they know what information is in the IRPG. Do not go into detail.	
This section discusses seven general steps involved with operating a single pump.	Slide 3-31
• Obtain equipment and supplies.	
• Set up and prime pump; connect hoses.	
• Mix gas and oil, and refuel.	
• Start pump.	
• Operate and maintain pump.	

OUTLINE	AIDS & CUES
• Shut down pump.	
• Troubleshoot.	
Use the pump kit to demonstrate these steps, as appropriate for the classroom.	
A. Obtain Equipment and Supplies	Slide 3-32
1. Pump or pump kit	
Typically, the pump operator's supervisor or someone else orders the pump kits. Often they will order extra pump kits to have as a backup.	
2. Other equipment supplies	
The pump operator needs to bring other equipment and supplies (e.g., fuel, discharge hoses, shovel, and nozzles).	
B. Set Up Pump, Connect Hoses, and Prime Pump	Slide 3-33
1. Select a site that is easily accessible. You will not always get an ideal site.	
• Find water source: Factors to consider include:	
– Amount of water available	
– Minimum of 1 foot deep	
– Cleanliness	
– Distance from fire	
– Environmental concern	

OUTLINE	AIDS & CUES
• Find flat ground or create flat ground; need enough room for two containment berms.	
• Keep suction lift as low as possible.	
• Minimize impact to site.	
2. Unpack kit; inventory and inspect equipment for damage.	
• Look for loose nuts or bolts, cracked suction hose, damaged threads, inoperative valves, holes in hose, and any other defects.	
• Flag defective items; identify the defect, problem, or symptom, and then return item.	
• Tie hose in knot if something is wrong with it.	
• Keep track of all contents in the kit so when it is repacked, everything is accounted for.	
3. Set up containment berms.	Slide 3-34
• Unfold both berms and ensure sides are fully extended. Remember to use two berms (one berm for the pump and the other for the fuel can).	
• Place absorbent pads in berms. In rough or rocky terrain, use two pads in pump berm.	

OUTLINE	AIDS & CUES
• Pads serve two purposes – to absorb fuel that is spilled and to protect the integrity of the berm.	
4. Place high pressure pump in one containment berm and the fuel can in the other berm.	
• Important: Because the pump engine has so many potential ignition sources, it is important to keep the fuel tank as far away from the engine as possible to avoid the ignition of any spilled or leaking fuel or fuel vapors.	
• Orient pump so exhaust does not vent directly on fuel can.	
5. Secure pump and fuel can, if necessary, to prevent creep and to maintain position.	Slide 3-35
Now that the pump, fuel can, and berms are set up, it is time to connect the hoses and prime the pump.	
6. Connect foot valve/strainer to male end of suction hose; then fill suction hose with water and connect to pump (suction side connections should be wrench-tight).	Slide 3-36
7. Place foot valve at least 1 foot under water.	
Keeping strainer clean and free of debris; puts strainer on a shovel, in a bucket, or other method to prevent it from becoming clogged with mud or gravel.	

OUTLINE	AIDS & CUES
8. Prime the pump by filling the priming port with water. Fill to the brim and wrench tighten cup. Fill the primary port using a hand primer or a pail.	Slide 3-37
9. Connect hose curl (pigtail) to discharge side of pump and the other end of hose curl to check and bleeder valve.	Slide 3-38
10. Utilize 1" port on check and bleeder valve to recirculate water back to the water source.	
The pressure relief valve can be added to the system to protect the pump from water hammer.	
C. Mix Gas and Oil, and Refuel	Slide 3-39
• Safety procedures when working with fuel:	Slide 3-40
– ALWAYS wear eye protection and gloves.	
– ALWAYS shut the pump down before opening the fuel tank.	
An operating pump engine has several potential sources of ignition including the muffler, exhaust, and electrical system. All of these ignition sources can be eliminated by shutting down the engine and allowing the exhaust to cool before opening the fuel tank.	
– NEVER operate a radio, cell phone, or other portable electronic device when working with fuel.	

OUTLINE	AIDS & CUES
• Fuel and environmental concerns	Slide 3-41
– Pumps and fuel cans often leak; preventing fuel from entering the water or ground is critical.	
– ALWAYS uses containment berms and absorbent pads.	
– ALWAYS mix fuel over the containment berm.	
– If a spill occurs or fuel enters the water source, contain the spill, ensure no more fuel is spilled, and notify supervisor, Resource Advisor, or both, immediately. Spill containment kits are available at district office and Incident Command Post.	
– If fuel has to be transported or stored, follow agency policy.	
Discuss agency policy for fuel transportation and storage.	
Refer to this publication:	
Interagency Transportation Guide for Gasoline, Mixed Gas, Drip-Torch Fuel, and Diesel (online at www.nwcg.gov/pms/pubs/442/pms442.pdf)	
• All two cycle pumps require unleaded gas mixed with two cycle oil.	Slide 3-42
• Determine if the fuel is pre-mixed.	Slide 3-43

OUTLINE	AIDS & CUES
– **Pre-mixed fuel** should be identified with a yellow tag (2-stroke mix) on the fuel can. The fuel is typically red or greenish (darker than straight gas), and slippery to the touch. Alaska and other areas provide pre-mixed fuel. If fuel is pre-mixed, it is ready to use.	
– **Regular gas** should be identified with a red tag; the gas is typically straw colored or clear (has no color). If the gas is unmixed, it needs to be mixed with two cycle oil.	
Ask students: What would happen if you put regular gas in a high pressure portable pump? • **Answer: Pump will seize due to inadequate lubrication.**	
• Fuel mixing instructions if the fuel was not pre-mixed:	Slide 3-44
– Determine quantity of regular gas and two cycle oil that needs to be mixed. Follow manufacturer's recommendation of **24:1.** **For every 5 gallons of gas, add approximately 1 quart of oil.**	
– Pour approximately 1 gallon of gas and an appropriate amount of two cycle oil into fuel can, and shake vigorously.	

OUTLINE	AIDS & CUES
– Add remainder of gas.	
• Write on tag the date the fuel was mixed and attach tag to fuel can.	Slide 3-45
• Attach fuel line to pump-adapted fuel can.	
• Replace fuel absorbent pads as needed by placing them in garbage bags (kit) and disposing of used pads according to local protocol.	
D. Start Pump	Slide 3-46
Follow these steps to start the pump. It is easy to flood the engine, so be careful.	
• Communicate to the nozzle operator(s) that pump is ready to start.	
• Don't start pump until nozzle operators have confirmed that they are ready for water.	
• Open air vent on fuel can.	
• If engine is cold, move the choke lever to start position. If engine is warm, move the choke lever to run position.	Slide 3-47
• Move throttle lever to start/warm up position.	
• Slowly pump fuel bulb until fuel mixture (in clear fuel tube) is just touching bottom of carburetor.	Slide 3-48
Caution – Follow this step carefully to avoid flooding the engine:	

OUTLINE	AIDS & CUES
• If pump is equipped with an on/off switch, turn the switch on.	Slide 3-49
• On Mark 3 pump, ensure overspeed reset rod is pushed in.	
• Pull starter rope with **short, quick pulls** (typically two to four pulls) until engine "pops."	
Click on sound icon to hear audio.	
• Immediately set choke lever to run position.	
• Pull starter rope approximately one to three more times, and the pump engine should start.	Slide 3-50
Caution – Any additional pulls of rope with choke in start position (after engine pops) will flood the engine.	
• Allow engine 2 minutes to warm up (throttle lever should still be at start/warm up position) before moving throttle to run position.	
E. Operate and Maintain Pump	Slide 3-51
• Prevent pump cavitation and water hammer.	
• Ensure water is flowing through the pump head at all times. Crack nozzle open or open bleeder valve.	
• Grease pump head with one squirt of grease once a shift (or every 8 to 12 hours) at grease/zerk fitting.	Slide 3-52

OUTLINE	AIDS & CUES
• When pump is shut down for fueling or maintenance, tighten any loose nuts and bolts.	
• Listen to the pump for indicators of how it is operating. The following are examples of sounds that may indicate problems with the pump or hose lay:	Slide 3-53
Click on respective sound icon to hear audio.	
– Lugging sound might indicate the pump's nozzle shut down, or there is a closed valve or kinked hose, or there are hydraulic or mechanical problems.	
– Rapidly increasing sound (revolutions per minute [rpm] increasing) may be a sign the pump has lost its prime, or there is a broken hose, broken suction hose, or an open nozzle.	
– Sputtering sound might indicate dirty air filter, bad fuel, or the pump's carburetor needs adjusting.	Slide 3-54
This section on adjusting the pump's carburetor is optional.	
The pump's carburetor is set to operate at specific elevations. A significant elevation change may cause fuel/air mixture problems and will result in the carburetor not working correctly.	

OUTLINE	AIDS & CUES
Consult with your supervisor or follow local policy, or both, regarding adjustment of the carburetor. If adjusting the carburetor is not allowed, flag the pump (identify problem on the flag) and return it to be fixed.	Slide 3-55
If you have permission to adjust the carburetor, follow these steps but be extremely careful because you may damage the pump.	
1. When the pump's engine is warm, run the pump at full throttle.	Slide 3-56
2. Slowly turn the high idle adjustment screw (with tabs) until maximum rpm is reached and passed (audible change).	
3. Turn the high idle adjustment screw the opposite direction until maximum rpm is reached again.	
4. Finally, turn the high idle adjustment screw counterclockwise ¼ of a turn to obtain both maximum rpm and proper engine lubrication.	
Click screen to play video on how to adjust carburetor.	
• Note: It is very important NOT TO ADJUST the low idle screw. Maladjustment of this screw will cause severe engine damage.	

OUTLINE	AIDS & CUES
F. Shut Down Pump Follow these steps when shutting down the pump: • Communicate with the nozzle operator that you are ready to shutdown the pump. • Move the throttle lever to the “stop” position. • Pull the male end of the fuel line quick-connect from the base of the fuel tank, and hold the fuel line (with fuel line still attached to the pump) above the tank to drain the fuel line. The pump will run at a low idle and have ample time to cool down and will stop due to the lack of fuel. • In freezing conditions, drain the pump head.	Slide 3-57
G. Troubleshoot Problems With Pump This section starts with a video on how to troubleshoot problems with the pump. Then two different approaches to troubleshooting will be described. 1. Troubleshooting video This video was produced before the current guideline, which describes the use of two berms (one berm for the pump and one for the fuel), was developed. The characters did not always wear full PPE or follow all proper fuel handling procedures. When the engine flooded, the characters should **not** have checked for a spark.	Slide 3-58

OUTLINE	AIDS & CUES
Tell students that they are going to see a video about starting, operating, and troubleshooting pumps. **Click on the image to play the video.**	
2. Troubleshooting – symptoms and remedies	Slide 3-59 to Slide 3-63
Refer to Troubleshooting Portable Water Delivery Systems (IR 3-2) for a list of common symptoms, causes, and remedies. This list specifically addresses problems with pump – it does not address problems with the suction hose.	IR 3-2 SR 3-2
Ask students questions to help them get familiar with using the symptom approach, for example: **1. The engine is running irregularly or misfires. What could be causing the problem? How would you fix it?** **2. The engine backfires. What could be causing the problem?** **3. The engine won't start. What could be causing the problem?**	
3. Troubleshooting using IRPG (step-by-step process) as a reference.	Slide 3-63
Have students find the troubleshooting section in the IRPG. Do not go over the information in detail, but make sure they know where to find it in the IRPG.	

OUTLINE	AIDS & CUES
4. Troubleshooting using the High Pressure Portable Pump Instructions (step-by-step process) as a reference.	Slide 3-64

Have students find the Troubleshooting section in the High Pressure Portable Pump Instructions.

The step-by-step process in the High Pressure Portable Pump Instructions (which is similar to the IRPG) is an excellent reference when troubleshooting. It comes in the High Pressure Portable Pump Kit.

The information in this reference is not in the Student Workbook, so it is very important to review each step listed on this reference.

Review the step-by-step process (using the slide) in detail – very important because the information is not in the Student Workbook.

5. Additional troubleshooting issues (not addressed in the IRPG or High Pressure Portable Pump Instructions) include:

- Check the air filter (Slide 3-65)

  Clean the air filter by removing it from the assembly, and clean it according to manufacturer's specifications. Reinstall the air filter components in the order they were removed (screen before filter).

OUTLINE	AIDS & CUES
• If the starter assembly is broken, follow these steps:	Slide 3-66
– Remove the starter housing to expose the manual pull cord starter assembly. Use caution around the pump after removing the starter housing as the starter is fully exposed and if you accidently touch it you will be severely injured.	
– Wrap a piece of rope or cord around the starter assembly, and pull to start the pump.	
6. Use flagging to identify mechanical or other problems with the pump.	Slide 3-67
We have just covered pump operator responsibilities from risk management to troubleshooting. Now it is time to address nozzle operator responsibilities.	
IV. NOZZLE RESPONSIBILITIES	Slide 3-68
The nozzle operator's close location to the fire increases his or her risk of injury. Also, if a simple hose lay is used, the nozzle operator does not have as much protection.	
A. Select Nozzle(s)	Slide 3-69
• Twin tip nozzles	
• Adjustable barrel nozzles	
• Sprinklers	
Refer to Types of Nozzles (HO 2-2) in Unit 2 (Equipment) for more information.	Previous HO 2-2

OUTLINE	AIDS & CUES
B. Apply Water	Slide 3-70
General guidelines for applying water include:	
• Situations where straight stream is appropriate include:	
– Fire is too hot to get close.	
– Fire is confined to small area.	
– Need to reach longer distances (snags, tree tops, hot roots or beds).	
• Situations where fog or spray nozzle is appropriate include:	
– Hot spotting, wet lining, direct attack, and mop up.	
– Close work is needed.	
– Fire covers a larger area.	
– A smaller volume of water is required to put out the fire or water conservation is necessary.	
• Approach fire with charged hose.	Slide 3-71
• Aim at base of flame, and maintain water stream in sweeping motion.	
• Avoid excessive water pressure.	Slide 3-72
High water pressure will deliver air as well as water to the fire and can fan the flame rather than knock it down. Excessive pressure wastes water while low pressure may not penetrate to the base of the flame.	

OUTLINE	AIDS & CUES
• Watch for flare-ups. • Conserve water (e.g., use low-flow nozzles, shut off as appropriate, apply water intermittently).	
Would you use straight stream or fog spray in each of the following four fire situations?	Slide 3-73

Image #1

OUTLINE	AIDS & CUES

Image #2

Image #3

OUTLINE	AIDS & CUES

Image #4

For each image, discuss with students possible answers.

Image #1: Straight stream
Image #2: Fog/spray
Image #3: Straight stream
Image #4: Fog/spray

C. Operation and Maintenance — Slide 3-74

- Slowly open and close all valves including nozzles to prevent water hammer.
- Unclog nozzle tips. — Slide 3-75

OUTLINE	AIDS & CUES
D. Communication	Slide 3-76
It is important to communicate up and down the hose lay to know how many nozzles can be open at a time. A hose lay may have 15 laterals, but sometimes the pump can only support 3 or 4 nozzles being open simultaneously.	
V. HOSE LAY RESPONSIBILITIES	Slide 3-77
The pump operator, nozzle operator, or others (i.e., hand crews) may be involved with setting up, maintaining, and retrieving hose lays.	
Throughout this section, discuss methods used locally.	
A. Set Up Hose Lay	Slide 3-78
There are numerous methods for setting up hose lays. A couple of methods are listed below:	
• Simple hose lay	
A crew first extends a trunk line (main hose line) from the pump to the fire as a simple hose lay; one nozzle is attached.	
Start with your largest hose, and then attach smaller hoses.	
Male fitting faces fire and female fitting faces water sources.	
• Progressive hose lay (hose lay with laterals lines)	Slide 3-79
Describe how lateral hose lines are set up using the progressive hose lay image on the slide.	

OUTLINE	AIDS & CUES
If lateral lines are needed, the crew can install a gated wye and proceed 100 feet with the trunk line to install another gated wye, which has a 1½″ to 1″ reducer on one side (towards the fire) and attach 100 feet of 1″ hose with the preferred nozzle. One person can then operate this nozzle to attack the fire as another person extends the next section of the trunk line, which is attached to the remaining side of the gated wye.	
Once the trunk line is extended and the second lateral gated wye is in place, the first nozzle operator then charges the trunk line and returns for more hose once the second lateral attack line is flowing water. This process is repeated until the fire is contained or the pump has reached capacity.	
Note: An inline T or other branching appliance could be used instead of the gated wye.	
B. Maintain and Retrieve Hose Lay	Slide 3-80
General guidelines for maintaining and retrieving hoses include:	
• Replace protective caps on accessories and male hose ends.	
• Be sure female ends have a gasket.	
• Replace broken hose and check for kinked hose.	

OUTLINE	AIDS & CUES
Ask students: What would be a symptom that the hose may be kinked? • **Answer: Not enough pressure at the nozzle.**	
• Keep hose line out of hot spots.	Slide 3-81
• Use accepted method of rolling hose when retrieving, e.g., figure eight or a roll. And reconnect male end into female end to protect threads.	
• Properly store hose in a safe location (away from fire, not in a dozer's path, etc.)	
VI. SETTING UP MULTIPLE PUMP SYSTEMS	Slide 3-82
This section discusses how to set up series, parallel, and staged pumping systems. Refer to Portable Pump Configurations for a review of these systems.	Previous HO 3-1
A. Series Pumping	Slide 3-83
1. Set up Pump 1.	
• Set up first pump near water source, and prime the pump.	
• Attach the short section of 1½″ hose to the pump discharge port, and attach a check and bleeder valve to the 1½″ hose.	
• Attach 1″ hose to check and bleeder valve to serve as pump protection and pressure relief.	

OUTLINE	AIDS & CUES
• Attach the female end of the hose you will use to connect the two pumps to the check and bleeder valve. The length of the connecting hose is dependent on the ability of the first pump to supply enough volume to the second pump.	
2. Set up Pump 2.	
• Attach a 1 ½″ double female coupling to the suction port. In some instances, it may be necessary to reduce the 2″ suction to 1½″.	
• Connect the hose from the first pump to the double female.	
• Connect a check bleeder valve to the discharge port using a short section of 1½″ hose.	
3. Double check all fittings and connections to prevent damaging pump or blowing hoses (due to increased pressure).	
4. Start Pump 1.	
• Start first pump and allow pump to warm up (water should be flowing toward the second pump).	
• Bring pump up to full operating speed.	
• Ensure water is flowing into the second pump. **The connecting hose should be firm.**	

OUTLINE	AIDS & CUES
5. Start Pump 2. • Start Pump 2 and allow it to warm up. • Slowly increase the speed of the second pump. The connecting hose should be monitored continually during operation. If the hose appears to quiver or go flat, the pump may be damaged (cavitation). This is because the second pump is drawing more water than the first pump can supply. Slow down the second pump or increase the speed of the first pump. 6. Monitor fuel levels. • Fuel levels must be monitored continually during the operations. ALWAYS shut down pump before checking fuel level or when refueling. Pumps will consume fuel at various rates based on inherent differences in the carburetor adjustments, throttle speeds, and mechanical conditions. 7. Shutdown procedures • Open the check and bleeder valve of Pump 2. This will reduce head pressure on the second pump. • Slow down Pump 2 to idle speed for cool down. • Slow down the Pump 1 to idle speed.	

OUTLINE	AIDS & CUES
• After both pumps have cooled down, turn them off.	
B. Parallel Pumping	Slide 3-84
Typically, one pump operator should be able to handle all setup and operation.	
1. Set up two pumps. Pumps should be relatively close together.	
• Attach a check and bleeder valve to each pump using a short 1½″ hose. The purpose of the check and bleeder valve in the line is to prevent head pressure and one pump from pumping back into the other.	
• Use a Siamese or invert a 1½″ gated wye by attaching a double male to the female end and two double females to the male ends of the wye. This allows for the connection of two pumps into one hose.	
• Attach the Siamese or inverted wye to the discharge hose of each pump using a length or lengths of hose.	
2. Either pump may be started or stopped at any time without affecting the other.	
3. Monitor fuel levels. ALWAYS shut down pump before checking fuel level or when refueling.	

OUTLINE	AIDS & CUES
4. Shutdown Procedures • Slow down both pumps to idle speed to cool down pumps. • Turn off pumps; they can be shut off in any order as long as there is a check and bleeder valve on the discharge side of each pump.	
C. Staged Pumping The steps for setup, operation, and shutdown for a staged pumping system are the same steps used if you are using a single pump.	Slide 3-85
VII. CHEMICALS (OPTIONAL) Chemicals are sometimes used with portable pumps. There are several types of wildland firefighting chemicals. The specific requirements, uses, and tactics for each type depend on the characteristics of the type of product.	Slide 3-86
Have students read this section on chemicals and then discuss relevancy to portable pumps.	
A. Types of Chemicals 1. Water enhancers Water enhancers contain ingredients designed to alter the physical characteristics of water to increase effectiveness, accuracy of the drop, or adhesion to fuels. They also improve the ability of water to cling to vertical and smooth surfaces.	

OUTLINE	AIDS & CUES
Once the water has evaporated, water enhancers are no longer effective. This makes them well suited for direct attack or short-duration indirect attack. They are also well suited to protection of structures and other vertical surfaces, as the viscosity and stickiness of the products reduces runoff and retains more of the product on the fuels. The duration of effectiveness will depend on temperature, humidity, and exposure to UV (sunlight). Water enhancers are supplied as wet or dry concentrates. They can be batch mixed or blended through proportioning equipment. Because some of these products are sensitive to the amount of shear that they are exposed to, during mixing, manufacturers' recommendations should be followed. Water enhancers are sensitive to water quality, and hard water will require a higher mix ratio than softer water to achieve the same consistency. Most are approved for use over a range of mix ratios to allow the user to obtain the consistency needed for the task. The water enhancers are typically applied from helicopters, Single Engine Air Tankers (SEATs), and ground equipment.	

OUTLINE	AIDS & CUES
2. Long-term retardants	

2. Long-term retardants

Long-term retardants contain retardant salts (typically fertilizers) that alter the way the fire burns, decreasing the fire intensity and slowing the advance of the fire, even after the water they originally contained has evaporated.

Because long-term retardants continue to work after the water they contain has evaporated and continue to work for days or weeks until they are removed by rain or erosion, they are well suited for indirect and line building. These products can be used for direct attack, but they are only marginally more effective than water for this use.

Retardants can be supplied as wet or dry concentrates. They have been developed to provide mixed product within a specific viscosity level. These concentrates are mixed with water at a mix ratio determined during the evaluation process. Mixing can occur at tanker bases and portable mixing sites to produce mixed retardant.

Application of long-term retardants is usually from fixed-wing air tankers and helicopters, but they may also be applied from ground equipment.

OUTLINE	AIDS & CUES

3. Foam fire suppressants

Foam fire suppressants contain foaming and wetting agents like those found in dishwashing detergents and other cleaners. The foaming agents affect the accuracy of an aerial drop, how fast the water drains from the foam, and how well the product clings to the fuel surfaces. The wetting agents increase the ability of the drained water to penetrate fuels.

Foams depend on the water that they contain to suppress the fire. Once the water has evaporated, foams are no longer effective. This property makes them most effective for direct attack and mop up.

Appropriate selection of concentrate dilution and application equipment will yield suppressants having a range of characteristics desirable for specific conditions:

a. Fast draining foam for penetration and wetting to attack deep seated fires and mop up.

b. Fluid foam with moderate drain times for wet line.

c. Dry, sticky foam with slow drain times for exposure protection.

Foam fire suppressants are supplied as wet concentrates. These concentrates can be batch mixed, blended with a proportioner, or prepared with a compressed air foam system.

OUTLINE	AIDS & CUES
Foams are typically applied from helicopters and ground equipment, although they may also be applied from SEATs. Some agencies may also apply foams from water-scooping aircraft.	
B. Personal Safety	
The material safety data sheet for each product must be available in the workplace. By following the recommendations for personal protective gear and safe handling procedures you will minimize your exposure to these products and any irritation they may cause.	
Common recommendations are that safety goggles be worn by anyone using concentrated liquid products such as foam concentrates, and dust masks should be worn when mixing dry concentrate retardants.	
Chapping and dry or cracked skin may occur with frequent or prolonged exposure to the drying effects of any of the fire chemicals. Washing any of these products off your skin as soon as possible and using a hand cream or protective lotion to minimize chapping is a good idea regardless of the products you are using.	
C. Environmental Concerns	
Most of the products have been evaluated for toxicity to fish. Because all of the products are toxic to fish to some extent, care should be taken to minimize the possibility of accidental contamination of all waterways.	

OUTLINE	AIDS & CUES
Chapter 12 of the Interagency Standards for Fire and Fire Aviation Operations contains specific guidelines and exceptions to these guidelines. All firefighters should become familiar with these guidelines and the actions to be taken if fire chemicals are introduced into the waterway. For most firefighters, their responsibility is to tell their supervisor if they see fire chemicals in a waterway, application of fire chemicals that impacts a waterway, or something that suggests that fire chemicals were introduced to a waterway.	
VIII. REVIEW	Slide 3-87
Review key points in the unit with PowerPoint slides. Answer any questions students have.	
Question 1. There is a fuel spill. What should you do?	Slide 3-88
Answer: Contain the spill; ensure no more fuel is spilled; notify supervisor or resource advisor immediately.	

OUTLINE	AIDS & CUES
Question 2. What are some risk management issues specific to operating a portable pump and hose lay?	Slide 3-89

Question 2. What are some risk management issues specific to operating a portable pump and hose lay?

Answer:

- **Wear full PPE**
  - **Pump operator needs to wear eye, ear, and hand protection**
  - **Nozzle operator needs to wear eye and hand protection.**
- **Ensure LCES is established and known. Nozzle operator at high risk of injury.**
- **Fuel handling requires additional safety precautions (i.e., no talking on the radio or cell phone).**
- **Follow first aid guidelines.**

Question 3. What are the four components that should be included in the design of a delivery system? (Slide 3-90)

Answer:

- **Pump configuration**
- **Hose lay design**
- **Nozzle type**
- **Hydraulic calculations, as appropriate**

OUTLINE	AIDS & CUES
Question 4. Critique this pump set up (see photo on slide). **Answer:** • **Pump and fuel can in one berm; should be in separate berms.** • **Pump and fuel can are not secured.** • **Muffler on pump facing fuel can.**	Slide 3-91
Question 5. When fueling or refueling, what are safety procedures the pump operator should follow? **Answer:** • **Wear full PPE, including eye and hand protection.** • **When pouring fuel or mixing gas with oil, do it over a containment berm.** • **Shut down pump before opening fuel can (i.e., to check fuel level).** • **Never operate a radio or electronic device when working with fuel.**	Slide 3-92
Question 6. When you start the pump, what can you do to prevent flooding the engine? **Answer: After engine "pops," don't pull rope with choke in start position.**	Slide 3-93

OUTLINE	AIDS & CUES
Question 7. You hear the pump lugging; what could be the problem?	Slide 3-94
Answer:	
• **Pump is running out of fuel.**	
• **Nozzle shut down.**	
• **Hydraulic or mechanical problems.**	
Question 8. You hear the pump having rapid rpms. What could be the problem?	Slide 3-95
Answer:	
• **Pump lost its prime.**	
• **Broken discharge hose.**	
• **Broken suction hose.**	
• **Open nozzle.**	
Question 9. What could cause the pump to lose its prime?	Slide 3-96
Answer:	
• **Suction hose connections are leaking.**	
• **Suction hose is defective.**	
• **Priming cap is loose.**	
• **Foot valve not fully submerged in water source.**	

OUTLINE	AIDS & CUES
Question 10. What can a pump operator do to prevent pump cavitation? **Answer:** • **Keep strainer clean and free of debris.** • **Locate pump as close to water source as practical.** • **Ensure adequate water supply.** • **Ensure diameter of suction hose is accurate.**	Slide 3-97
Question 11. What can a pump and nozzle operator do to prevent water hammer? **Answer:** • **Slowly close valves and nozzles.** • **Slightly crack open nozzles at all times.** • **Protect hoses from being driven over.**	Slide 3-98
Question 12. In what situations would it be advantageous for the nozzle operator to use the straight stream? **Answer:** • **Fire is too hot to get close.** • **Fire is confined to small area.** • **A lot of pressure is needed to reach long distance (snags, tree tops, hot roots or beds).**	Slide 3-99

OUTLINE	AIDS & CUES
Question 13. In what situations would it be advantageous for the nozzle operator to use the fog/spray? **Answer:** • **Hot spotting, wet lining, direct attack, and mop up** • **Close work is needed.** • **Fire covers a larger area.** • **A smaller volume of water is required to put out the fire or water conservation is necessary.**	Slide 3-100
Question 14. What are some general guidelines for applying water? **Answer:** • **Approach fire with charged hose.** • **Aim at base of flame and maintain water stream in sweeping motion.** • **Avoid excessive water pressure.** • **Conserve water (i.e., use low-flow nozzles, shutoff as appropriate, apply water intermittently).** • **Watch for flare-ups.**	Slide 3-101

OUTLINE	AIDS & CUES
Question 15. What are some general guidelines for maintaining and retrieving hoses? **Answer:** • **Replace protective caps on accessories and male hose ends.** • **Be sure female ends have a gasket.** • **Replace broken hose.** • **Check for kinked hose.** • **Keep hose line out of hot spots.** • **Use accepted method of rolling hose when retrieving, e.g., figure eight or a roll.** • **Properly store hose in a safe location (away from fire, not in a dozer's path, etc.).**	Slide 3-102
Review Unit Objectives.	Slide 3-103 Slide 3-104

State of Alaska
Department of Natural Resources
Division of Forestry

Director's Office
550 W. 7th Ave., Suite 1450
Anchorage, Alaska 99501-3566

Safety Office
101 Airport Road, Aviation Hanger
Palmer, Alaska 99645

This document is intended as a safety and training tool, an aid to preventing similar future occurrences, and to inform interested parties. The information contained in this report is subject to revision upon further investigation and/or should additional information become available.

ACCIDENT INVESTIGATION FACTUAL REPORT

Type of Incident:
Water Supply / Burns

Location:
AK-DOF, Fairbanks Area, Logging Slash Fire, Alaska

Date of Accident/Incident:
July 9th, 2009

Investigation Team Members:

Rocky D. Ansell, Statewide Safety Officer, State of Alaska, Division of Forestry, Palmer

Tom Kubichek, Alaska Smokejumpers Air Operations Supervisor, BLM/AFS, Fairbanks

Mike Spencer, Safety Officer / Training Specialist, Pacific N/W Regional Office, USFS

Special commendations are warranted for the quick actions of the other personnel present on the Logging Slash Fire. They quickly reacted to the situation, encouraged the Pump Operator to “Stop, Drop and Roll” and provided immediate emergency care. These actions greatly reduced the degree of injury and significantly reduced the recovery time of the injured party.

Christian Blankenship	Incident Commander
Glen Farnsworth	Operations
Avi Shalom	Fairbanks Area WFRT IV
Mike Goyette	Fairbanks Area Prevention Officer

The investigation team would like to thank everyone assigned to the Minto Flats South IMT (Alaska Type 2 Green Team) for their cooperation.

Rob Allen	Incident Commander
Kato Howard	Operations Section Chief
Rich Webster	Safety Officer
Terri Berrie	Medical Unit Leader

Per the guidance provided to the investigation team by the Agency Representatives, this investigation utilized a modified After Action Review format.

The investigation team referenced the following documents for guidance in their efforts to obtain information, complete their findings and document this incident:

- Interagency Standards for Fire and Fire Aviation Operations 2009
  - Chapter 7, Safety & Risk Management
  - Chapter 18, Reviews, Investigations & Analyses
- State of Alaska, Policies and Procedures Manual, Section 2165

Summary

At approximately 1857 hours (ADST) on July 9th, 2009 while supporting a water pumping operation, a member of the Idaho City IHC was burned while working on the Logging Slash Fire in interior Alaska. The Idaho City IHC Crew Member was assigned the operation of a Mark 3 pump to support a water pumping function utilizing a folda-tank and Mark 3 pump. During a routine check of the fuel supply the crew member opened the Jerry can (fuel tank); flammable liquid and vapors spewed from the container and were ignited. The resulting flash fire burned the crew member. Investigation reveals the jerry can, during set-up of the pump, was placed in close proximity to the Mark 3 exhaust (muffler). During the interval that the pump was running the exhaust did impinge upon the jerry can preheating the gasoline. Upon opening the bung of the jerry can; volatile gasoline vapors and liquid escaped and were ignited by the muffler/hot components of the Mark 3 pump. Portable fire extinguishers were used to extinguish the fuel can, pump and other burning objects that had been ignited by the flash fire.

A designated medivac helicopter from an adjacent fire was dispatched while medical personnel on scene began treatment of the injured crew member and prepared him for transport. The injured crew member was rapidly transported to a Fairbanks hospital and after an evaluation by physicians, was then transferred to a Seattle burn center. The crew member spent several days in the intensive care unit of the burn center where his condition rapidly improved and was released from the hospital on 07/22/2009. He continues to convalesce and is expected to make a full recovery.

Conditions

The Logging Slash Fire (#73911404) was reported to the Fairbanks Area Office of the Alaska Division of Forestry by the FAA Flight Tower as 2 acres, smoldering approximately 20 miles southwest of Fairbanks, Alaska on 07/08/2009. Weather conditions obtained from the closest RAWS sites indicate temperatures at the time of the accident were in the high 80's to low 90's, relative humidity 33%, winds NNE at 10 mph and no recent precipitation. Assessment by the responding Incident Commander was the fire's behavior was extreme, with some crowning, spotting with 40 to 50 foot flame lengths.

The accident occurred at the ICP/Staging Area of the Logging Slash Fire which was located near N63:56:00 x W148:45:08. This area may be accessed from the Parks Highway near Mile Marker 342, taking the Old Nenana Road exit, following the Standard Creek Road then following a single lane logging road for approximately 26 miles.

Personnel Assigned As Of 07/09/2009

Type 3 IMT
Delta #2 Type 2 Crew
Idaho City IHC (temporarily re-assigned from Minto Flats South Fire)

Sequence of Events

07/07/09
- 1000 hours
  - Idaho City IHC arrived in Fairbanks from Boise
- 1700 hours
  - Minto Flats South ICP (Nenana), assigned structure protection on 73911320, (Crew received multiple briefings including "no spills in drill pad")

07/08/09
- 0800 hours
  - Set-up pumps, sprinklers and hose lays around Doyon Arctic Wolf drill site

07/09/09
- 1030 hours
  - Idaho City IHC temporarily re-assigned to Fire 73911420

1857 hours
  Accident occurs, burning Idaho City IHC crew member
1952 hours
  Burn victim arrives Fairbanks Memorial Hospital via Helicopter N16973
2315
  Burn victim prepared for transport to Seattle via Guardian Flight, Inc – estimated flight time 3.5 hours

Narrative

Five Type 1 crews were mobilized from the Lower-48 to Alaska to support multiple incidents. The Idaho City IHC (IC-IHC) was one of these crews. The IC-IHC was assigned to the Minto Flats South Fire (#73911320) on July 7th, 2009. The IC-IHC did receive an Alaska Briefing prior to being assigned to the incident. When the crew was sent to the Minto Flats South ICP, the Crew Superintendant and other senior members of the crew were provided an "environmental" briefing regarding work practices and reporting of spills while working on the Doyon Arctic Wolf drill pad, this included the use of spill containment, sorbent pads and the reporting of any fluids that come in contact with the pad. The Crew Superintendant then relayed this information to the IC-IHC members. The IC-IHC were assigned the task of developing a water supply utilizing portable pumps, a hose lay and deploying sprinklers on the drill pad for the protection of the Doyon Arctic Wolf drilling rig.

On July 9th, 2009 the IC-IHC were reassigned to a new fire named the Logging Slash. Upon arrival at the staging area the crew was assigned the task of developing a water supply utilizing Mark 3 pumps, folda-tanks and a hose lay to supply water to assist with suppression of this fire. The IC-IHC was working with the Delta #2 Type 2 Crew.

A member of the IC-IHC (Pump Operator) was assigned the task of deploying the #2 pump in the water supply operation. This pump and folda-tank was located in the staging area/ICP of the incident. After about 2 hours of operation the Pump Operator checked the Mark 3 pump and decided to check the fuel level of the jerry can that was supplying the fuel to the pump. The Pump Operator did reduce the RPM of the pump, and then proceeded to remove the bung from the jerry can. As the bung was being removed from jerry can, vapors and liquid escaped; came in contact with the hot muffler and engine components of the Mark 3 pump, igniting the vapors. The resulting flash fire was significant enough to cause injury to the Pump Operator.

Upon hearing a the sound of igniting fuel and indicators that a person was hurt, personnel in close proximity to the #2 pump operation reacted swiftly to assist the Pump Operator. Another crew member of the IC-IHC was known to have advanced EMT skills and was ordered to the scene of the accident. The Logging Slash IC promptly requested a medivac. A short discussion ensued between Fairbanks Area Dispatch, the Logging Slash IC, and the Operations Section Chief of the Minto Flats South fire regarding the appropriate helicopter to be used (Fairbanks Area IA ship or the ship from the Minto

Flats South Fire). In just a few minutes the decision was made to utilize helicopter N16973, which had a medic ready to respond and was closer geographically. Helicopter N16973 landed at the Logging Slash Staging Area/ICP, the injured Pump Operator was loaded and flown directly to Fairbanks Memorial Hospital.

As the injured Pump Operator was admitted to the hospital, Administrative personnel from the Division of Forestry, assisted by a Comp Claims Specialist from the BLM/Alaska Fire Service began assisting with notifications and educating hospital staff regarding the Federal Wildland Firefighter Burn Injury Protocols. After initial treatment and evaluation, a fixed wing medivac was arranged to transport the Pump Operator from Fairbanks to Harborview Burn Center in Seattle, Washington.

Injuries

Initially reported as 1st and 2nd degree burns with possible 3rd degree to face, arms and hands. Field medic assessment identifies facial/ears, hands, forearms and leg burns, estimated to cover 25% of body surface.

Causal Factors and Findings

- Placement of the jerry can in close proximity to Mark 3 muffler and in an angled alignment with the exhaust.

- Size/shape of fuel containment dyke may have been a contributing factor in the placement of the jerry can next to the muffler. The investigation team recommends additional research regarding whether the fuel containment dyke does readily lend itself to safe and practical set-up / operation while adhering to containment standards.

- Briefing IC-IHC received regarding very strict spill prevention and reporting may have been interpreted to include all incidents.

Note: The pump and jerry can were removed from the scene of the accident prior to the arrival of the investigators. Both the Mark 3 pump and jerry can, along with other components present at the scene were inspected at the secure storage facility in Fairbanks. Detailed pictures were taken on scene shortly after the accident. Inspection revealed no mechanical deficiencies with the pump and/or fueling system. The air vent on the jerry can was open.

Applicable Information and Issues

The injured member of the Idaho City IHC is a fully qualified Firefighter Type 1. A check of his training records finds that he completed annual Fire Safety Refresher on April 27, 2009, completed work capacity testing (arduous) and has taken Portable Pump & Water Use (S-211) on August 1st, 2001

Recommendations

- ✓ Educate all wildland suppression agencies and organizations of the Burn Injury Criteria that is present in Chapter 7 of the 2009 Interagency Standards for Fire and Fire Aviation Operations.
- ✓ Update NWCG S-211 course to include more information regarding the proper use of spill containment devices and importance of keeping the jerry can away from muffler side of pumps
- ✓ Place a label near fuel line port of jerry can stating "Do Not Place Can Near Exhaust"
- ✓ All training should emphasize the proper use of PPE including eye and hand protection during all fueling operations
- ✓ All training should address the utilization of Crew Resource Management during any emergency
- ✓ All wildland fire suppression organizations/agencies should develop a "Safety Gram" to emphasize the dangers of placing fuel containers too close to mufflers or other sources of ignition

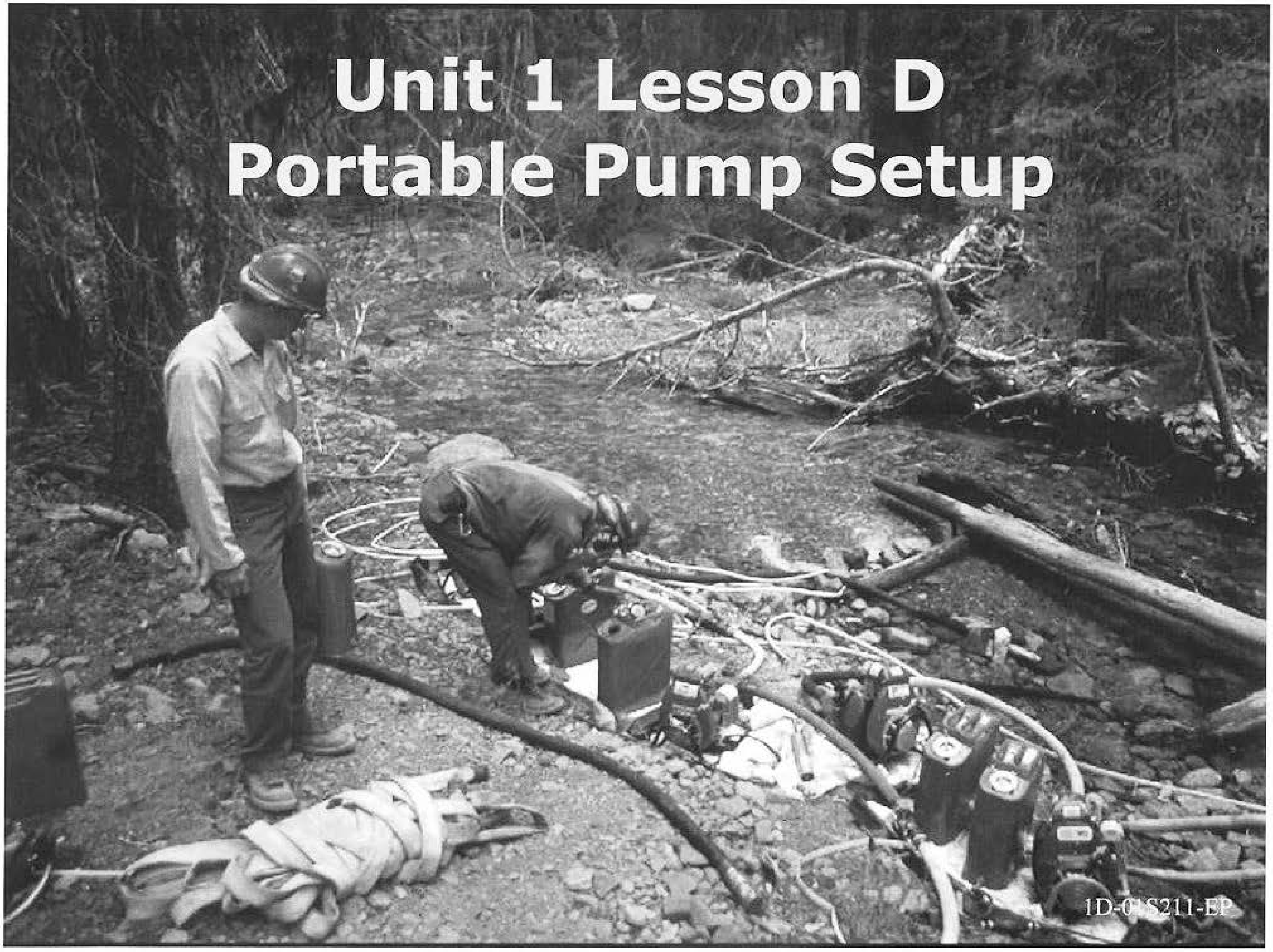
Supporting Documentation:

Photographs (list)

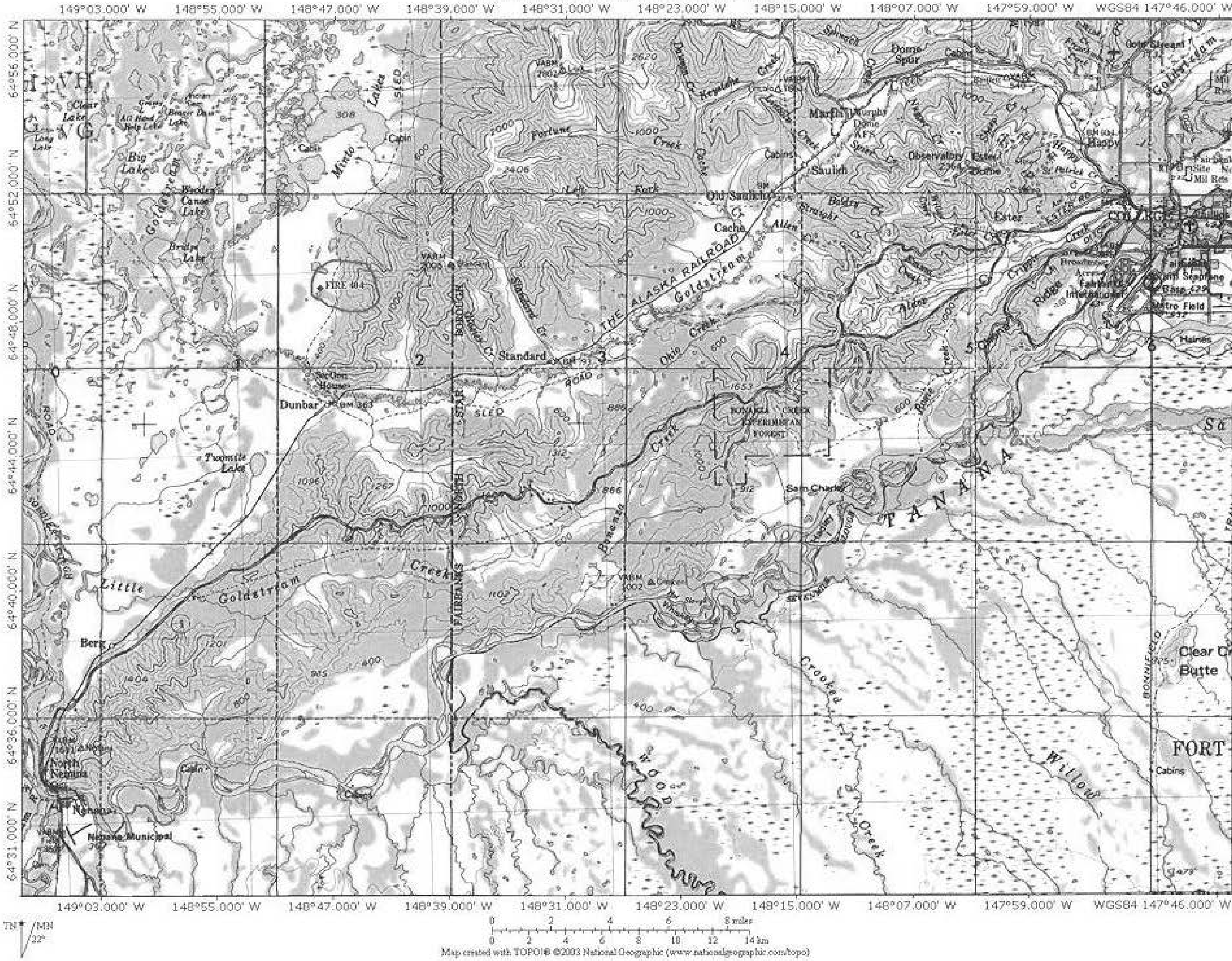
Photo 1	Mark 3 Pump, Jerry Can & Folda-tank
Photo 2	Mark 3 Pump & Jerry Can
Photo 3	Slide from Unit 1, Lesson D, S-211 Class
Photo 4	TOPO Map


07.09.2009 19:38
1149


07.09.2009 19:39


Unit 1 Lesson D
Portable Pump Setup

TOPO! map printed on 07/24/09 from "RDA July 2009.tpo"



Map created with TOPO!® ©2003 National Geographic (www.nationalgeographic.com/topo)

Troubleshooting Portable Water Delivery Systems
Symptoms and Remedies

Symptom: Engine does not start or starts momentarily and then stops.	
Possible Cause	**Remedy**
Fuel supply tank empty.	Refill fuel tank.
Fuel supply valve closed.	Open supply valve.
Air vent on fuel tank closed.	Open air vent or unscrew cap.
Defective fuel supply hose.	Replace.
Dirty fuel strainer screen.	Clean or replace.
Leak in fuel supply system.	Tighten or replace fittings.
Carburetor mountings loose.	Tighten mountings.
Water or dirt in fuel system.	Drain, and then flush thoroughly.
Too much oil in fuel mixture.	Mix new batch of fuel.
Engine flooded.	Dry the engine.
Air filter dirty.	Clean or replace.
Spark plug fouled or defective.	Clean or replace.
No spark.	Cannot repair in field. Use flagging to identify problem, and return the pump to warehouse.

Symptom: Engine runs irregularly or misfires.	
Possible Cause	**Remedy**
Defective fuel supply hose.	Replace.
Dirty fuel strainer screen.	Clean or replace.
Leak in fuel supply system.	Tighten or replace fittings.
Carburetor mountings loose.	Tighten mountings.
Water or dirt in fuel system.	Drain, and then flush thoroughly.
Wrong gasoline in fuel mixture.	Mix new batch of fuel.
Too much oil in fuel mixture.	Mix new batch of fuel.
Air filter dirty.	Clean or replace.
Spark plug fouled or defective.	Clean or replace.
Wrong type spark plug.	Use recommended plug.

Symptom: Engine backfires.	
Possible Cause	**Remedy**
Spark plug fouled or defective.	Clean or replace.

Symptom: Engine does not idle properly.	
Possible Cause	**Remedy**
Carburetor mountings loose.	Tighten mountings.
Too much oil in fuel mixture.	Mix new batch of fuel.
Spark plug fouled or defective.	Clean or replace.
Wrong type spark plug.	Use recommended plug.

Symptom: Engine does not develop normal power, overheats, or both.	
Possible Cause	**Remedy**
Carburetor mounting loose.	Tighten mountings.
Wrong gasoline in fuel mixture.	Mix new batch of fuel.
Wrong oil in fuel mixture.	Mix new batch of fuel.
Not enough oil in fuel mixture.	Mix new batch of fuel.
Too much oil in fuel mixture.	Mix new batch of fuel.
Air filter dirty.	Replace.
Spark plug fouled or defective.	Clean or replace.
Wrong type of spark plug.	Use recommended plug.
Muffler blocked or dirty.	Replace.

Symptom: Engine sounds like a four stroke engine.	
Possible Cause	**Remedy**
Too much oil in fuel mixture.	Mix new batch of fuel.
Engine not warmed up properly.	Allow longer warmup period.
Air filter dirty.	Clean or replace.

UNIT OVERVIEW

Course Portable Pumps and Water Use, S-211

Unit 4 – System Design and Hydraulics

Time 3–4 Hours
1 Hour – Classroom Final Exam

Objectives

1. List one reason it is important for a pump and nozzle operator to have a basic understanding of hydraulics.
2. Given scenarios, determine flow and pump discharge pressure, and select appropriate pump(s).
3. Given scenarios, draw a schematic of the design of a water delivery system, and troubleshoot the delivery system.
4. Given scenarios, determine whether parallel hose lay, series pumping, or parallel pumping would be the best option.

Strategy

This unit introduces design and hydraulic concepts that are important to water delivery systems. We start the unit with a definition of hydraulics and why it is important. Then we describe the three-step process to determining if a delivery system is hydraulically feasible for a hose lay with no laterals, a hose lay with different size hoses, and a hose lay with laterals. Next, we discuss advanced delivery systems (e.g., parallel hose lay, series pumping, parallel pumping), specifically how they impact pressure and flow. Lastly, we cover troubleshooting and designing a delivery system from a hydraulic perspective. Several scenarios are included to teach students the concepts.

Instructional Methods

- Informal lecture and discussion with PowerPoint
- Exercises and scenarios
- This PowerPoint presentation contains several animations. Review these animations before instruction.
- Slide 4-17 is an interactive animation of a friction loss calculator. Instructions on opening the calculator animation are written on the slide. To use the calculator, click on the slider and you will be able to move it back and forth with the mouse. Practice using the interactive friction loss calculator before instruction.
- The Pump Discharge Pressure calculations were determined using the calculator that is depicted in the interactive animation. If a different calculator is used, expect those answers to be different than the ones in the course.

Instructional Aids

- ☐ Computer with LCD projector, presentation software, and screen
- ☐ Flip chart and markers
- ☐ Incident Response Pocket Guide (IRPG)
- ☐ Fire Stream/Nozzle Discharge & Friction Loss Calculator

Exercises

- Troubleshooting a Water Delivery System From a Hydraulic Perspective
- How to Design a Hydraulically Sound Water Delivery System

Evaluation Methods

- Oral review session at end of the unit.
- Objectives will be tested in Classroom Final Exam (written).

Outline

Write the unit outline on flip chart paper. The outline should look like this:

I. Introduction

II. Three-Step Process to Determine if Water Delivery System Will Work

III. Hose Lay With No Laterals

IV. Hose Lay (No Laterals) With Different Size Hoses

V. Hose Lay With Laterals

VI. Advanced Water Delivery Systems

VII. Troubleshooting the Delivery System From a Hydraulic Perspective

VIII. Designing a Water Delivery System Using Hydraulic Concepts

IX. Review

Aids and Cues Codes

The codes in the Aids and Cues column are defined as follows:

IG – Instructor Guide
SW – Student Workbook
HO – Handout
IR – Instructor Reference
SR – Student Reference
Slide – PowerPoint

UNIT PRESENTATION

Course: Portable Pumps and Water Use, S-211

Unit: 4 – System Design and Hydraulics

OUTLINE	AIDS & CUES
Unit Title Slide.	Slide 4-1
Click on audio icon to hear firefighter story about pumps.	Slide 4-2
Present Unit Objectives.	Slide 4-3 Slide 4-4
Refer students to unit outline on flip chart; review main headings so students can see big picture and stay on track.	
I. INTRODUCTION	Slide 4-5
A water delivery system can be as simple as one pump, one hose, and one nozzle, or it can be a complex system of several pumps, several hoses, and several nozzles.	Slide 4-6
If the goal of a water delivery system is to provide proper flow and pressure to meet the tactical objectives – how does the crew boss, squad boss, and/or pump operator determine:	Slide 4-7
• What pumping configuration(s) will work?	
• What hose lay design will work (i.e., hose diameter, hose length, laterals)?	
• What type of nozzle(s) to use?	

OUTLINE	AIDS & CUES
In many situations, these decisions are made through trial and error, which is a time-consuming process that is not an efficient use of resources, time, and effort.	Slide 4-8
Fireline personnel can reduce a lot of this guesswork by planning ahead and applying basic hydraulic concepts. Know ahead of time – before setting it up – if the system will work.	
A. Hydraulics is the science and engineering that deals with fluids at rest and in motion.	Slide 4-9
B. Why is having a basic understanding of hydraulics important?	Slide 4-10
1. To ensure proper amount of water and pressure is delivered to the nozzle(s).	
2. To determine equipment needed, keep it working, and prevent damage.	
3. To design and troubleshoot the water delivery system.	
4. To help ensure a safe work environment.	
II. THREE-STEP PROCESS TO DETERMINE IF WATER DELIVERY SYSTEM WILL WORK	Slide 4-11
There is a three-step process to determine if a water delivery system will work. These steps help ensure that the pump is capable of providing required flow and pressure to the nozzle(s).	
Does this three-step process need to be used for every water delivery system encountered in the field?	
No, especially with simple delivery systems. But, when the delivery systems get to be more complex (e.g., more pumps, more laterals), going through the steps is critical.	

OUTLINE	AIDS & CUES
A. Step 1 – Determine Flow Rate	Slide 4-12
• **Flow** rate is the amount of water in gallons per minute (gpm) discharged through the hose lay.	
• Note: The terms flow and discharge are used interchangeably. Typically, “flow” is used when talking about the hose lay (water is flowing through the hose lay), and “discharge” is used when talking about the nozzle (water flow is being discharged out the nozzle).	
• How to determine flow rate will be discussed in the next section.	
B. Step 2 – Calculate Pump Discharge Pressure	
Pump Discharge Pressure (PDP) is the **pressure** in pounds per square inch (psi), required to deliver a specific pressure and flow at the nozzle.	
PDP is measured at the pump panel.	
How to determine PDP will be discussed in the next section.	
C. Step 3 – Determine What Types of Pumps Are Capable of Providing Flow and PDP (Pump Performance)	
In Unit 2 (Equipment), pump performance was defined as the **flow (gpm)** and **pressure (psi)** that the pump is capable of providing (refer to the chart, Portable Pump Performance – National Cache Pumps [HO 2-1]).	Previous HO 2-1

OUTLINE	AIDS & CUES
The three-step process will be explained in detail for the following situations:	
• Hose lays with no laterals	
• Hose lays (with no laterals) that have different size hoses	
• Hose lays with laterals	
III. HOSE LAYS WITH NO LATERALS	Slide 4-13
This section will describe the three-step process for hose lays without laterals (simple hose lays).	Slide 4-14
A. Step 1 – Determine Flow Rate	Slide 4-15
1. The type of nozzle(s) on the hose lay determines flow rate.	
Note: Tactical objectives determine what type of nozzle is used.	
Nozzles have different flow rates, for example:	
• Twin tip nozzle with 3/16″ tip has a flow rate of 7 gpm at 50 psi.	
• Adjustable barrel nozzle with 1″ tip has a flow rate of 20 gpm at 100 psi.	
2. To find the flow rates for different nozzles, refer to the IRPG or use the nozzle discharge calculator. The nozzle's manufacturer also provides flow rates.	Slide 4-16
• IRPG	

OUTLINE	AIDS & CUES
The IRPG provides flow rates for commonly used nozzle types and sizes.	
Refer students to the IRPG. **Ask students: What is the flow rate for a 1″ adjustable barrel nozzle?** • **Answer: 20 gpm**	
• Nozzle Discharge Calculator	Slide 4-17
Use the nozzle discharge calculator to determine flow rates for various types of nozzles.	
Note: This calculator is traditionally referred to as the "friction loss calculator"; however, it is really comprised of two different calculators: nozzle discharge calculator and friction loss calculator.	
Follow instructions on the slide to open the interactive calculator (Slide 4-17). To use the calculator, click on the slider and move it back and forth with the mouse. **Orient students to the nozzle discharge calculator by pointing out:** • **Nozzle pressure (psi)** • **Discharge (gpm)** • **Nozzle bore (tip)** **Then use the calculator to demonstrate the next steps.**	
– First, align the nozzle pressure with the arrow.	

OUTLINE	AIDS & CUES
For example, you are using a 3/16″ tip, which is operated at 50 psi; align 50 psi with the arrow.	
– Next, read the discharge (flow) above "NOZZLE BORE."	
For example, what is the flow from a 3/16″ tip (which has 50 psi)? Answer: 7 gpm	
– Round answers.	
Rounding and not rounding can lead to different answers, especially with long hose lays.	
– Remember, this is not an exact science – the goal is to get an estimate.	
– Practice: What is the flow rate from a 3/8″ tip at 50 psi?	Slide 4-18
__________	

Answer: 30 gpm

B. Step 2 – Calculate PDP	Slide 4-19
Use this formula to calculate PDP:	Slide 4-20
NP ± HP + FL = PDP	
NP = Nozzle Pressure **HP = Head Pressure** **FL = Friction Loss** **PDP = Pump Discharge Pressure**	

OUTLINE	AIDS & CUES
1. Nozzle Pressure (NP)	Slide 4-21
Click on slide image to view animation.	
• Nozzle pressure is the pressure that the nozzle is designed to operate at most efficiently. The unit for NP is psi.	
• The type of nozzle that is on the hose lay determines the nozzle pressure. The nozzle pressure in the formula will be either 50 psi or 100 psi, because the two commonly used nozzles in wildland fire are the twin tip nozzle (50 psi) and the adjustable barrel nozzle (100 psi). These nozzles are designed to operate most efficiently at 50 or 100 psi; however, they will operate at lower or higher pressures.	Slide 4-22
• The IRPG lists the nozzle pressure for each type of nozzle.	Slide 4-23
Direct students to find nozzle pressure information in the IRPG and review the data.	
2. Head Pressure (HP)	Slide 4-24
Click on the image on the right to play the animation; it will start in a few seconds.	

OUTLINE	AIDS & CUES

- Head pressure or head is the pressure exerted by a column of water. The amount of pressure required to raise water 1 foot (1 pound of psi will lift water 2 feet).

  The unit for HP is psi.

- To determine head pressure, you need to know the vertical distance from the pump to the nozzle, and whether it is an uphill or downhill elevation change.

  Note: Head pressure has nothing to do with hose length or diameter.

- How do you calculate head pressure? — Slide 4-25

  – The head pressure formula is based on the guideline that 1 psi lifts water 2 feet:

±HP	**=**	**Number of feet in elevation change from pump to nozzle**	÷	**2 psi/1 ft**

  – If there is no elevation change (level ground), HP = 0.

  – If there is an uphill hose lay, ADD head pressure in the PDP formula.

Ask students: Why is HP added in the formula when there is an uphill hose lay?

- **Answer: Because more pressure is needed to move the water uphill.**

OUTLINE	AIDS & CUES
– If there is a downhill hose lay, SUBTRACT head pressure in the PDP formula.	
• General Rule: HP is ½ the elevation rise or fall. Uphill elevation – add to the formula; downhill elevation – subtract from the formula.	Slide 4-26
Ask students: Based on the image on the slide, what is the head pressure? Would you add or subtract it in the PDP formula? • **Answer: 50 psi; add it in the formula.**	
• Practice:	Slide 4-27
– The nozzle is 250 feet (elevation change) uphill from the pump. What is the head pressure? _________________	
Answer: +125 psi	
– The nozzle is 100 feet (elevation change) downhill from the pump. What is the head pressure? __________________	
Answer: -50 psi	

OUTLINE	AIDS & CUES

– The nozzle is 250 feet (elevation change) downhill from the pump. What is the head pressure?

____

Answer: -125 psi

3. Friction Loss (FL) — Slide 4-28

• What is friction loss?

Friction loss refers to the loss of pressure due to water turbulence and resistance along the inside wall of the hose.

The unit for FL is psi.

Click on image to play animation.

• Why is friction loss important? — Slide 4-29

Because the pump has to overcome the loss of pressure (from friction in the hose lay) to provide adequate pressure to the nozzle.

• How is friction loss calculated? — Slide 4-30

Use this formula:

FL per 100′ section of hose lay	x	Number of 100′ sections of hose lay	=	Total FL for hose lay

OUTLINE	AIDS & CUES
Use the IRPG or the friction loss calculator to determine **friction loss per 100′ section of hose lay** for the specific flow and hose diameter of the hose lay (these are the inputs).	
– What is the total friction loss for 100′ of 1″ hose with flow rate of 30 gpm?	Slide 4-31

FL per 100′ section of hose lay	x	Number of 100′ sections of hose lay	=	Total FL
23 psi		1		23 psi

• Practice	Slide 4-32
– In this practice, use the IRPG to find the FL per 100′ section of hose lay for the specified hose diameter and flow.	
– What is the total FL for 300′ of 1½″ hose with flow rate of 30 gpm?	

FL per 100′ section of hose lay	x	Number of 100′ sections of hose lay	=	Total FL

Answer: 3 psi x 3 sections of 100′ hose = 9 psi

OUTLINE	AIDS & CUES
• Use the friction loss calculator.	Slide 4-33

- Use the friction loss calculator.
  - There will be situations when the IRPG does not provide the friction loss information that is needed. In those situations, the friction loss calculator can be used to determine friction loss for specific hose diameter and flow.
  - Become oriented to the friction loss calculator by finding the flow (gpm), psi loss per 100 ft single line and size of hose. And then follow these steps:

Orient students to the friction loss calculator by pointing out:

- **Flow (gpm)**
- **Psi loss per 100 ft single line**
- **Size of hose**

At the bottom of the calculator is "psi loss per 100 ft 2 Siamese lines" = tell students to ignore this for now; they will not be using it in the class.

- **Use the interactive calculator (Slide 4-33) to demonstrate the next steps.**

First, align flow rate with the arrow.

Next, read friction loss opposite hose size diameter.

OUTLINE	AIDS & CUES

For example, if flow rate is 30 gpm, what is the friction loss in 3/4″ hose?

Answer: 100 psi per 100′

What is the friction loss for 30 gpm (flow rate) through 1½″ hose?

Answer: 3 psi per 100′

The answer was determined using the calculator on the slide. Other calculators may provide different answers.

– Practice

What is the total friction loss for 300′ of 1″ hose with flow rate of 30 gpm? — Slide 4-34

FL per 100′ section of hose lay	x	Number of 100′ sections of hose lay	=	Total FL
23 psi	x	3	=	69 psi

What is total friction loss for 300′ of ¾″ hose @ 30 gpm? — Slide 4-35

FL per 100 feet section in hose lay	x	Number of 100 feet sections in hose lay	=	Total FL
100 psi	x	3	=	300

OUTLINE	AIDS & CUES
• Friction Loss Principles	Slide 4-36
This section discusses three friction loss principles. These principles help explain the relationship between friction loss and flow, hose diameter, and hose length.	
– **Principle: When flow (gpm) decreases friction loss decreases (when hose diameter is constant).**	Slide 4-37

Click on slide image to view animation.

Practice: Flow rate is 40 gpm. What is friction loss in 1″ hose? _______________	Slide 4-38

Answer: 40 psi per 100′

Practice: Flow rate is 20 gpm. What is friction loss in 1″ hose? _______________

Answer: 10 psi per 100′

If flow increases, would friction loss increase or decrease?

Answer: Increase
Tell students that, in general, if the flow is doubled, friction loss increases four times.

– Principle: When hose diameter increases, friction loss decreases.	Slide 4-39

OUTLINE	AIDS & CUES
Click on slide image to view animation.	
Practice: Flow rate is 30 gpm. What is the friction loss in 1″ hose? _______________	Slide 4-40
Answer: 23 psi per 100′ **Click on "link to calculator" to show students how to use the calculator to get this answer.** **This link is on several slides – click on it as appropriate to help students understand how to use the calculator.**	
Practice: Flow rate is 30 gpm. What is the friction loss in 1½″ hose? _______________	
Answer: 3 psi per 100′	
Note: The 1″ hose has approximately 7 times the friction loss of 1½″ hose.	
– Principle: Longer hose lengths have increased friction loss.	Slide 4-41
Practice: Flow rate is 20 gpm. What is friction loss in 100′ of 1″ hose? ____________________	Slide 4-42
Answer: **Friction loss in 100′ of 1″ hose = 10 psi**	

OUTLINE	AIDS & CUES
Practice: Flow rate is 20 gpm. What is friction loss in 300′ of 1″ hose? _______________	Slide 4-43

Answer:
Friction loss in 300′ of 1″ hose = 30 psi
(10 psi per 100′ x 3 lengths of hose = 30 psi)

4. Add the numbers together to determine Pump Discharge Pressure (PDP) — Slide 4-44

We have just discussed how to determine nozzle pressure, head pressure, and friction loss. Now it is time to put it all together and determine **pump discharge pressure.**

Remember, PDP is the pressure required to deliver a specific pressure and flow at the nozzle. And, it is measured at the pump panel.

Use this formula to calculate PDP:

NP ± HP + FL = PDP

NP = Nozzle Pressure

HP = Head Pressure

FL = Friction Loss

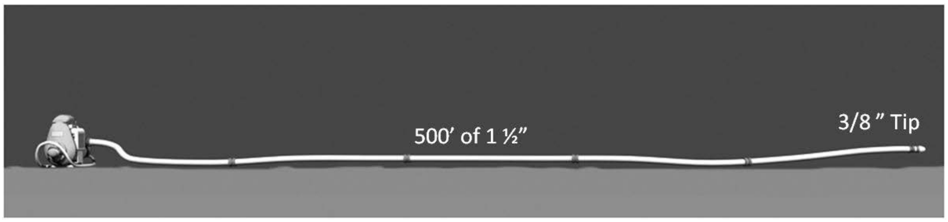
PDP = Pump Discharge Pressure

We will use Scenario A to demonstrate how to calculate PDP.

OUTLINE	AIDS & CUES

Scenario A: The hose lay has 500′ of 1½″ hose; one Forester nozzle with a 3/8″ tip attached. There is no elevation difference between the nozzle and pump.

Slide 4-45



Step 1: What is flow rate?

Slide 4-46

Flow rate for 3/8″ tip = 30 gpm

Step 2: What is PDP?

Nozzle Pressure (3/8″ tip)	=	+50 psi
Head Pressure There is no elevation difference.	=	0 psi
Friction Loss (for 500′ of 1½″ hose @ 30 gpm)	=	+15 psi

Math:
100′ of 1½″ hose @ 30 gpm = 3 psi
3 psi x 5 lengths of 100′ hose = 15 psi

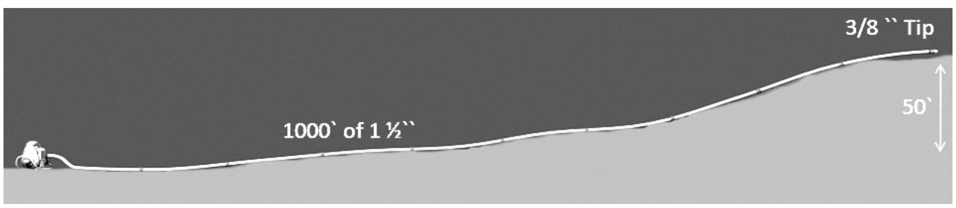
PDP = 65 psi

Ensure students understand how friction loss (15 psi) was determined. Review the math.

Scenario A requires a flow of 30 gpm and pump discharge pressure at 65 psi.

OUTLINE	AIDS & CUES
You have now learned how to complete Steps 1 and 2. Now it is time for the last step.	
C. Step 3 – Identify What Types of Pumps Are Capable of Providing Flow and PDP (for the Hose Lay)	Slide 4-47
Using the Portable Pump Performance – National Cache Pumps (HO 2-1), identify the pump(s) that can provide 30 gpm at 65 psi for the hose lay in Scenario A.	Slide 4-48 Previous HO 2-1
Answer: Mark 3; Wick 375.	
You can also refer to the IRPG for the Mark 3 pump performance data. However, the IRPG does not correspond directly with the values in the Portable Pump Performance– National Cache Pumps (HO 2-1). Pump flows are normally given in 50 psi increments; the performance information in the IRPG is reported in 10 gpm increments.	Previous HO 2-1
D. Scenarios	
Scenarios B, C, and D provide more opportunities to practice the three-step process.	

OUTLINE	AIDS & CUES
• **Scenario B**: The hose lay has 1,000′ of 1½″ hose; one Forester nozzle with 3/8″ tip attached. Nozzle is located 50′ above the pump.	Slide 4-49
– Step 1: What is flow rate?	
– Step 2: What is PDP?	
– Step 3: Identify what types of pumps are capable of providing flow and PDP.	



Step 1: Flow rate = 30 gpm (Slide 4-50)

Note: 3/8″ tip

Step 2: Calculate PDP.

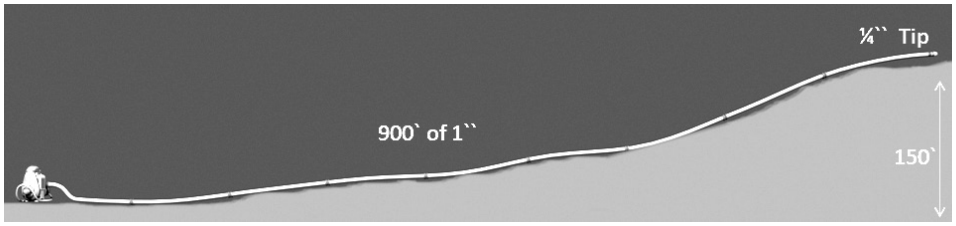
Nozzle Pressure (3/8″ tip)	=	+50 psi
Head Pressure (50′ ÷ 2 psi/1″) ADD head pressure due to uphill elevation.	=	+25 psi
Friction Loss (for 1000′ of 1½″ hose @ 30 gpm)	=	+30 psi

Math:
100′ of 1½″ hose @ 30 gpm = 3 psi
3 psi x 10 lengths of 100′ hose = 30 psi

PDP = 105 psi

OUTLINE	AIDS & CUES
Ensure students understand how total friction loss (30 psi) was determined. Go slow and review the math.	
Remind students to always write down + or - for head pressure.	
Step 3: Identify what types of pumps are capable of providing flow and PDP.	
Using the Portable Pump Performance – National Cache Pumps (HO 2-1), *w*hat pump(s) can provide 30 gpm at 105 psi for this hose lay?	Previous HO 2-1
Answer: Mark 3; Wick 375	
If you have any questions or need clarification, ask the instructor for assistance. The scenarios will get more difficult, and understanding the basics is essential.	
• **Scenario C:** The hose lay has 900′ of 1″ hose; one Forester nozzle with ¼″ tip attached. Nozzle is located 150′ above the pump.	Slide 4-51
– Step 1: What is flow rate?	
– Step 2: What is PDP?	
– Step 3: Identify what types of pumps are capable of providing flow and PDP.	

OUTLINE	AIDS & CUES



Step 1: Flow rate = 13 gpm — Slide 4-52

Note: 1/4″ tip

Step 2: Calculate PDP.

Nozzle Pressure (for Forester nozzle with ¼″ tip)	=	+50 psi
Head Pressure (150′ ÷ 2 psi/1″) ADD head pressure due to uphill elevation.	=	+75 psi
Friction Loss (for 900′ of 1″ hose @ 13 gpm)	=	+36 psi

Math:
100′ of 1″ hose @ 13 gpm = 4 psi
4 psi x 9 lengths of 100′ hose = 36 psi

PDP = 161 psi

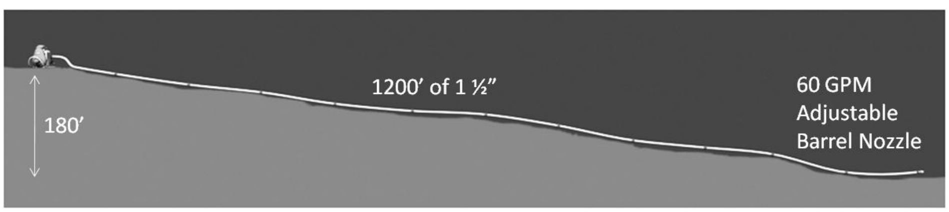
Ensure students understand how total friction loss (30 psi) was determined. Go slow and review the math.

Step 3: Identify what types of pumps are capable of providing flow and PDP.

OUTLINE	AIDS & CUES
Using the Portable Pump Performance – National Cache Pumps (HO 2-1), what pump(s) can provide 13 gpm at 161 psi for this hose lay?	Previous HO 2-1

Answer: Mark 3; Wick 375

- **Scenario D**: The hose lay has 1200′ of 1½″ hose; one 60 gpm adjustable barrel nozzle. Nozzle is located 180′ below the pump. (Slide 4-53)
  - Step 1: What is flow rate?
  - Step 2: What is PDP?
  - Step 3: Identify what types of pumps are capable of providing flow and PDP.



Step 1: Flow rate (given) = 60 gpm (Slide 4-54)

Note: All prior scenarios had a twin tip nozzle; this is the first scenario with an adjustable barrel nozzle.

OUTLINE	AIDS & CUES
Step 2: Calculate PDP.	
Nozzle Pressure (for adjustable barrel) = +100 psi The nozzle pressure is 100 psi because this scenario has an adjustable barrel nozzle.	
Head Pressure (180′ ÷ 2 psi/1″) = - 90 psi SUBTRACT head pressure due to downhill elevation change.	
Friction Loss = +156 psi (for 1200′ of 1½″ hose @ 60 gpm)	
Math: 100′ of 1½″ hose @ 60 gpm = 13 psi 13 psi x 12 lengths of 100′ hose = 156 psi	
PDP = 166 psi	
Ensure students understand how total friction loss was determined. Go slow and review the math.	
Step 3: Identify what types of pumps are capable of providing flow and PDP.	
Using the Portable Pump Performance – National Cache Pumps (HO 2-1), what pump(s) can provide 60 gpm at 166 psi for this hose lay?	Previous HO 2-1
Answer: Mark 3; Wick 375	

OUTLINE	AIDS & CUES

You have just gone through several scenarios on how to determine PDP for hose lays **without laterals**. Now, you will learn how to determine PDP for a hose lay that has different size hoses.

Ask students if they have questions about determining PDP for hose lays without laterals. Ensure they understand the process before moving on to the next section. If students need more practice, develop other examples.

IV. HOSE LAY (NO LATERALS) WITH DIFFERENT SIZE HOSES — Slide 4-55

A. Process Is Slightly Different

Determining flow rate and PDP for a hose lay with different size hoses is very similar to what you have already learned; the only difference is in how friction loss is calculated. — Slide 4-56

Step 1: Flow Rate (same process)

Step 2: PDP

- NP (same process)
- HP (same process)
- Friction loss (different process)

  Friction loss is calculated for each hose size and then added together to get total friction loss.

Step 3: Identify pump (same process)

Scenario E will demonstrate the steps.

OUTLINE	AIDS & CUES
B. Scenario E	Slide 4-57

The hose lay has 500′ of 1½″ hose, which is reduced down to 100′ of 1″ hose. One Forester nozzle with 3/8″ tip attached. There is no elevation difference between the pump and the nozzle.

- Step 1: What is flow rate?
- Step 2: What is PDP?
- Step 3: Identify what types of pumps are capable of providing flow and PDP.

Step 1: Flow rate = 30 gpm — Slide 4-58

Note: 3/8″ tip

OUTLINE	AIDS & CUES
<u>Step 2</u>: Calculate PDP.	
Nozzle Pressure (for Forester nozzle with 3/8″ tip) = +50 psi	
Head Pressure (no elevation change) = 0 psi	
Friction Loss (for 100′ of 1″ hose @ 30 gpm) = +23 psi	
Friction loss (for 500′ of 1½″ hose @ 30 gpm) = +15 psi	
Math: 100′ of 1½″ hose @ 30 gpm = 3 psi 3 psi x 5 lengths of 100′ hose = 15 psi	
PDP = 88 psi	
Ensure students understand how total friction loss was determined. Go slow and review the math.	
<u>Step 3</u>: Identify what types of pumps are capable of providing flow and PDP.	
Using the Portable Pump Performance – National Cache Pumps (HO 2-1), what pump(s) can provide 30 gpm at 88 psi for this hose lay?	Previous HO 2-1
Answer: Mark 3; Wick 375	

OUTLINE	AIDS & CUES
V. HOSE LAY WITH LATERALS	Slide 4-59
A. Process Requires More Steps	Slide 4-60

When a hose lay has laterals, how does the step-by-step process change?

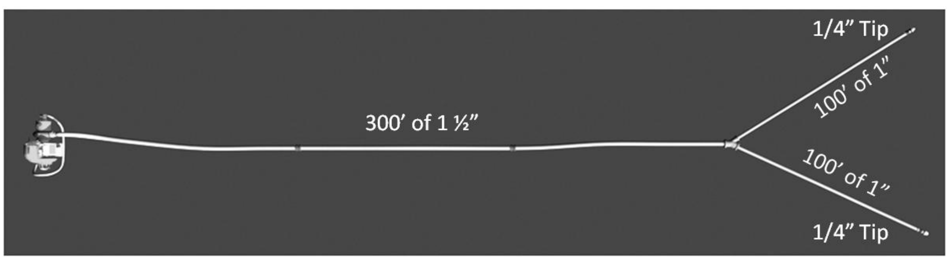
- Step 1: Flow rate (slightly different process)
  - Calculate flow in all laterals to determine flow rate in each section of the trunk.
- Step 2: PDP
  - Nozzle pressure (same process)
  - Head pressure (same process)
  - Friction loss (slightly different process)

    Calculate FL for only 1 lateral; the lateral that has the potential for the most friction loss. It could be the lateral with the highest flow or the lateral with the longest hose.

    Calculate FL for each section of the trunk.
- Step 3: Identify pumps (same process)

Scenarios F and G will illustrate how to calculate PDP for hose lays with laterals. In these scenarios, the term "trunk" refers to the hose that comes straight off the pump. "Laterals" refer to the hoses that are added to the trunk using a "hose line tee or wye valve" (lateral junction).

OUTLINE	AIDS & CUES
B. Scenarios	
• **Scenario F:** The hose lay has 300′ of 1½″ hose with a gated wye that goes into two 100′ 1″ laterals, each with ¼″ tip. There is no elevation difference between the pump and nozzle.	Slide 4-61
– Step 1: What is flow rate?	
– Step 2: What is PDP?	
– Step 3: Identify what types of pumps are capable of providing flow and PDP.	



Students will need to use the Calculator (NFES 0897) for this scenario.

Step 1: What is flow rate? — Slide 4-62

Calculate flow in all laterals to determine flow rate in each section of the trunk.

Flow rate in lateral A (¼″ tip)	=	13 gpm
Flow rate in lateral B (¼″ tip)	=	13 gpm
Total flow rate in all laterals	=	26 gpm
Flow rate in trunk (300′ of 1½″)	**=**	**26 gpm**

OUTLINE	AIDS & CUES

Therefore, the 300′ of 1½″ hose must supply 26 gpm in order for laterals A and B to each deliver 13 gpm.

Step 2: Calculate PDP

Nozzle Pressure (for Forester nozzle with ¼″ tip)	=	+50 psi

Note: Do not add nozzle pressures.

Head Pressure (no elevation change)	=	0 psi
Friction Loss – Lateral A (for 100′ of 1″ @ 13 gpm)	=	4 psi

Note: Calculate friction loss for only 1 lateral. Choose the lateral that has the potential for the most friction loss; it could be the lateral with the highest flow or the lateral with the longest hose. And, make sure to use the gpm for the lateral chosen.

Friction Loss – Trunk (for 300′ of 1½″ @ 26 gpm)	=	+6 psi

Math:
100′ of 1½″ hose @ 26 gpm = 2 psi
2 psi x 3 lengths of 100′ hose = 6 psi

Note: Calculate the friction loss for each section of the trunk; in this scenario, there is only 1 trunk.

PDP	**=**	**60 psi**

OUTLINE	AIDS & CUES

Ensure students understand how total friction loss was determined. Go slow and review the math.

Step 3: Identify what types of pumps are capable of providing flow and PDP.

Using the Portable Pump Performance – National Cache Pumps (HO 2-1), what pump(s) can provide 26 gpm at 60 psi for this hose lay?

Previous HO 2-1

Answer: Mark 3; Wick 375

- **Scenario G:** The hose lay has 700′ of 1½″ hose until the first lateral. Then there is another 100′ of 1½″ hose to the second lateral and another 100′ of 1½″ hose to the third lateral. All laterals have 100′ of 1″ hose and ¼″ tips. There is no elevation difference between the pump and nozzle.

  Slide 4-63

  – Step 1: What is flow rate?

  – Step 2: What is PDP?

  – Step 3: Identify what types of pumps are capable of providing flow and PDP.

OUTLINE	AIDS & CUES
Step 1: What is flow rate?	Slide 4-64
Calculate FLOW in all laterals to determine flow rate in each section of the trunk.	

Flow rate in lateral A (¼″ tip)	=	13 gpm
Flow rate in lateral B (¼″ tip)	=	13 gpm
Flow rate in lateral C (¼″ tip)	=	13 gpm
Total flow rate in all laterals	=	39 gpm

Calculate FLOW in each section of the trunk.

Flow rate – trunk Z (100′ of 1½″ hose)	=	13 gpm
Flow rate – trunk Y (100′ of 1½″ hose)	=	26 gpm
Flow rate – trunk X (700′ of 1½″ hose)	=	39 gpm

OUTLINE	AIDS & CUES

Step 2: Calculate PDP.

Nozzle Pressure (for Forester nozzle with for ¼″ tip)	=	+50 psi

Note: Do not add nozzle pressures.

Head Pressure (no elevation change)	=	0 psi
Friction Loss – Lateral C (for 100′ of 1″ @ 13 gpm)		4 psi

Note: Calculate friction loss for only 1 lateral. Choose the lateral that has the potential for the most friction loss; it could be the lateral with the highest flow or the lateral with the longest hose. And, make sure to use the gpm for the lateral chosen. In this scenario, all the laterals are the same flow, so it doesn't matter which lateral is selected.

Friction Loss – Trunk Z (for 100′ of 1½″ hose @ 13 gpm)	=	0 psi
Friction Loss – Trunk Y (for 100′ of 1½″ hose @ 26 gpm)	=	2 psi
Friction Loss – Trunk X (for 700′ of 1½″ hose @ 39 gpm)	=	35 psi

Math:
100′ of 1½″ hose @ 39 gpm = 5 psi
5 psi x 7 lengths of 100′ hose = 35 psi

Note: Calculate the friction loss for each section of the trunk. Start at the end of the hose lay and work back to the pump. Make sure to use the flow rate that is specific for each section of the trunk.

PDP	**=**	**91 psi**

OUTLINE	AIDS & CUES

Remember that rounding can impact answers.

Ensure students understand how total friction loss was determined. Go slow and review the math.

Step 3: Identify what types of pumps are capable of providing flow and PDP.

Using the Portable Pump Performance – National Cache Pumps (HO 2-1), what pump(s) can provide 39 gpm at 91 psi for this hose lay? — Previous HO 2-1

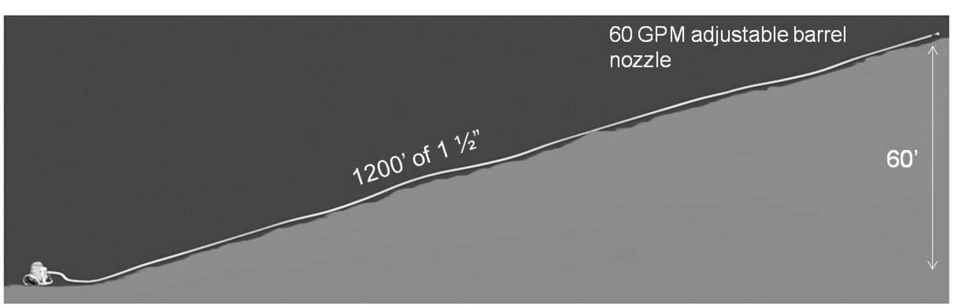
Answer: Mark 3; Wick 375

VI. ADVANCED WATER DELIVERY SYSTEMS — Slide 4-65

There are going to be situations, such as significant elevation rise and/or long hose lay, when a simple water delivery system is NOT going to be able to provide the needed pressure and flow. In these cases, advanced delivery systems need to be considered.

An example of such a situation is shown in Scenario H. — Slide 4-66

Scenario H: The hose lay has 1200′ of 1½″ hose. One 60 gpm adjustable barrel nozzle. Nozzle is located 60 feet above the pump.



Step 1: Flow rate = 60 gpm (given)

OUTLINE	AIDS & CUES
Step 2: Calculate PDP.	
Nozzle Pressure (60 gpm adjustable barrel nozzle) = +100 psi	
Head Pressure (60 feet uphill rise) = + 30 psi	
Friction loss = +156 psi	
PDP = 286 psi	
Step 3: Identify what types of pumps are capable of providing flow and PDP.	
Using the *Portable* Pump Performance – National Cache Pumps (HO 2-1), what pump(s) can provide 60 gpm at 286 psi for this hose lay?	Previous HO 2-1
Answer: There are NO pumps that are capable of producing 286 psi at 60 gpm. The Mark 3 can produce 286 psi, but it can only provide 30 gpm at that pressure. **In situations such as this, there are other options that should be considered such as using a parallel hose lay or multiple pump system.**	
A. Parallel Hose Lay	Slide 4-67
A parallel hose lay is an example of how changing the hose lay can reduce friction loss, which then reduces pump discharge pressure.	
1. Refer to Types of Hose Lays (HO 3-2) for a general description and characteristics of parallel hose lay.	Previous HO 3-2

OUTLINE	AIDS & CUES

- What is the main advantage of a parallel hose lay?

Answer: It reduces friction loss, which then reduces the PDP.

- What is a general guideline to determine the friction loss for parallel hose lay?

Answer: Generally, parallel hose lays have ¼ the friction loss of a single line hose lay.

2. Parallel hose lay and Scenario H. Will parallel hose lay work?

   Slide 4-68

   If the Scenario H design was changed to a parallel hose lay design, how would that impact flow and pump discharge pressure? Assume parallel hose lay decreases friction loss by approximately ¼.

		Scenario H	**Scenario H and Parallel Hose Lay**
Step 1: Flow rate	=	60 gpm	60 gpm
Step 2: PDP			
Nozzle Pressure	=	+100 psi	+100 psi
Head Pressure	=	+30 psi	+30 psi
Friction Loss	=	+156 psi	+39 psi*
PDP		286 psi	169 psi

*The friction loss of 39 psi was determined by using the general rule that a parallel hose lay decreases friction loss by approximately ¼ (156 psi ÷ 4 = 39 psi). This is an estimate.

Answer: Flow does not change. Friction loss decreases, which resulted in PDP decreasing from 286 psi to 169 psi.

OUTLINE	AIDS & CUES
The purpose of this section is for students to understand that a parallel hose lay decreases friction loss. This is not about everyone getting the same answer. **Students may try to calculate friction loss using the calculator and they will come up with slightly different answers than 39, especially when they round.**	
The Mark 3 and the Wick 375 can provide 60 gpm at 169 psi for this hose lay (refer to the Portable Pump Performance – National Cache Pumps [HO 2-1])	Previous HO 2-1
Optional – ask students: If the flow was doubled, how would that impact friction loss? • **Answer: Quadruple the friction loss**	
B. Series Pumping	Slide 4-69
1. Refer to Portable Pump Configurations (HO 3-1) for a general description and characteristics of series pumping.	Previous HO 3-1
• Series pumping is a way to increase pump performance (by using more than one pump), which will increase pressure.	
• When using series pumping, the pressures of both pumps are combined, but flow stays the same. For example, one Mark 3 pump can provide 60 gpm at 170 psi. If another Mark 3 pump is added in series, the combination will provide 60 gpm at 340 psi.	

OUTLINE	AIDS & CUES

- Series pumping is often used to overcome significant elevation rise, long hose lay, or whenever more pressure is needed.
- What happens if the first pump fails?

Answer: The system fails.

2. Series pumping and Scenario H. Will series pumping work? — Slide 4-70

The purpose of this section is for students to understand that series pumping increases pump performance by increasing pressure but not flow.

- Will series pumping be able to provide the flow (60 gpm) and PDP (286 psi) that Scenario H required?

		Scenario H	**Series Pumping and Scenario H**
Step 1: Flow rate	=	60 gpm	60 gpm
Step 2: PDP			
Nozzle Pressure	=	+100 psi	+100 psi
Head Pressure	=	+30 psi	+30 psi
Friction Loss	=	+156 psi	+156 psi*
PDP		286 psi	286 psi

Answer: Yes, the Mark 3 can produce 60 gpm at 170 psi. If two Mark 3 pumps are set up as series pumping, they can provide 60 gpm at 340 psi. Since this hose lay requires 60 gpm at 286 psi – the two Mark 3 pumps (set up as series pumping) will work. This is also true for the Wick 375 pump.

OUTLINE	AIDS & CUES
When pumps are used in series, pressures from each pump are combined (for example, 170 psi + 170 psi = 340 psi) with no change in flow.	
C. Parallel Pumping	Slide 4-71
1. Refer to Portable Pump Configurations (HO 3-1) for a general description and characteristics of parallel pumping.	Previous HO 3-1
• Parallel pumping is a way to increase pump performance (by using more than one pump), which <u>increases flow</u>, but not the pressure.	
General rule is that it doubles the flow.	
When pumps are used in parallel, flow from each pump is added together with no change in pressure.	
• Describe a field situation when parallel pumping would be a good option.	

Answer: To fill tanks, drop tanks, or whenever more flow is needed.

OUTLINE	AIDS & CUES
2. Parallel pumping and Scenario H. Will parallel pumping work?	Slide 4-72

- Will parallel pumping be able to provide the flow (60 gpm) and PDP (286 psi) that Scenario H required?

		Scenario H	**Parallel Pumping**
Step 1: Flow rate	=	60 gpm	60 gpm
Step 2: PDP			
Nozzle Pressure	=	+100 psi	+100 psi
Head Pressure	=	+30 psi	+30 psi
Friction Loss	=	+156 psi	+156 psi*
PDP		286 psi	286 psi

Answer: Yes. The Mark 3 can produce 30 gpm at 285 psi. If two Mark 3 pumps are set up for parallel pumping, then together they can provide 60 gpm at 286 psi. This is also true for the Wick 375 pump.

D. Review — Slide 4-73

OUTLINE	AIDS & CUES
VII. TROUBLESHOOTING THE DELIVERY SYSTEM FROM A HYDRAULIC PERSPECTIVE	Slide 4-74

The key to troubleshooting from a hydraulic perspective is to understand the relationships among all the different components in the system. This takes time and a lot of field experience.

Troubleshooting often starts with trying to determine what the problem is and then figuring out what equipment (e.g., pumps, hose, appliances) is available to fix it. For example, if the problem is too much friction loss, using a larger diameter hose (if there is one available) would solve the problem, but there isn't one available; another option is to use a parallel hose lay, if there is enough hose for that option.

This section introduces troubleshooting from a hydraulic perspective; using pump discharge pressure and pump capability as the starting point.

- Pump discharge pressure (Slide 4-75)

  Look at each of the components in the pump discharge pressure (PDP) formula to determine what may be causing the problem and to identify possible solutions:

  - Nozzle pressure

    Change the type of nozzle, tip size, or both, to reduce pressure.

  - Head pressure

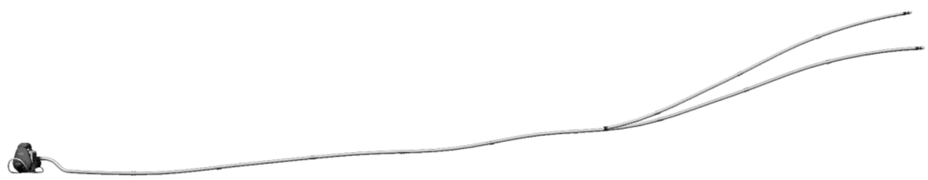
    Move the pump to a different location (to reduce head pressure); but this often isn't an option.

OUTLINE	AIDS & CUES
– Friction loss There are several options for reducing friction loss, such as increase hose diameter, shorten hose length, use a parallel hose lay, and/or reduce flow. • Pump capability – How can pump capability be changed to meet the flow and PDP requirements? – Use a pump that has higher performance capabilities – pressure and flow. – Use a series pumping system to increase pressure. – Use a parallel pumping system to increase flow.	
EXERCISE: **Troubleshooting a Water Delivery System From a Hydraulic Perspective**	Slide 4-76
Purpose: Students (small groups) will troubleshoot a water delivery system using their understanding of hydraulics. Time: 15 minutes Materials Needed: Flip chart paper and markers (for each group) Exercise Instructions: This exercise is designed to be flexible; instructors can tailor it to meet their needs. Instructors can use the exercise the way it is written or they can make it more specific by telling students what types of equipment (e.g., types of pumps) are available.	

OUTLINE	AIDS & CUES

1. Direct students to read exercise directions in Student Workbook:

Directions:
This hose lay was set up, but water isn't discharging through the nozzle with sufficient workable pressure.



Slide 4-77

Nozzle Pressure	=	+50 psi
Head Pressure	=	+200 psi
Friction Loss	=	+150 psi
PDP	=	400 psi
FLOW	=	60 gpm

For each troubleshooting factor listed below, identify how it could be changed and what impact it would have on the system.

This exercise will help students see the interrelationships among all the components. Below are possible answers for each factor. Students may identify other answers.

- Pump discharge pressure

- **Find a water source further up the slope to reduce head pressure requirement.**
- **Increase hose diameter to reduce FL.**
- **Use parallel hose lay to reduce friction loss.**

- Pump capability

OUTLINE	AIDS & CUES
• Use a pump with higher pressure output to overcome the pressure requirement. **• Series pumping may work if friction loss can be decreased.**	
Be prepared to present and discuss your answers.	
2. Discuss answers. Have each group present how they addressed the whole problem. As a recap, go through each of the factors and highlight the main points.	
Point out that changing any aspect of the system will have an effect on the system. The real answer depends on the pumps and equipment available to the operator – so using any pump system is possible with the correct equipment and supplies and an understanding of the system.	
End of Exercise.	
VIII. DESIGNING A WATER DELIVERY SYSTEM USING HYDRAULIC CONCEPTS	Slide 4-78
In Unit 3 (Responsibilities), you learned that simple water delivery systems can be designed using a mental image, but more complicated systems should be designed on paper – to ensure they are hydraulically feasible.	
The delivery system design should include the following:	
Use this hand-drawn design to point out the following items that should be in the design.	Slide 4-79 IR 4-1 SR 4-1
• Portable pump configuration (including types of pumps)	

OUTLINE	AIDS & CUES
• Hose lay design (trunks and laterals) including hose diameter and length	
• Nozzle type, tip size, or both	
• Hydraulic calculations	
– Flow (gpm)	
– Pump discharge pressure (nozzle pressure, head pressure, friction loss)	
This next exercise will give you practice in designing a delivery system that is hydraulically feasible.	
EXERCISE: How to Design a Hydraulically Sound Water Delivery System	Slide 4-80
Purpose: Students (small groups) will develop a schematic of a water delivery system and determine flow, PDP, and nozzle pressure of system. Then they will present their design to the large group.	
Time: 30 – 45 minutes	
Materials Needed: Flip chart paper and markers (for each group)	
Instructions:	
1. Divide students into small groups.	
2. Direct students to read exercise directions in Student Workbook:	
Directions: Your squad is mopping up a ½-acre spot fire burning in heavy slash. There is a 200-foot elevation change from the pump site (river) to the fire and the distance is 2,000 feet. The following equipment is available:	Slide 4-81

OUTLINE	AIDS & CUES

- 2 Mark 3 pumps
- 2 MK 26 pumps
- 2500′ of 1½″ hose
- 500′ of 1″ hose
- 3 Forester nozzles with 3/16″ tip
- 3 adjustable barrel nozzles (1″)
- Assorted appliances and adapters

Question 1: On the flip chart paper, draw a schematic (design) that is hydraulically feasible – the schematic needs to include the pump configuration, hose lay design, and nozzle types.

Question 2: Determine pump discharge pressure (nozzle pressure, head pressure and friction loss), and write it on the schematic.

Be prepared to present your answers to the large group. There are many solutions.

3. When students are finished, have each group present and discuss the answers to the questions. There is no answer key because there are many solutions.

End of Exercise.

OUTLINE	AIDS & CUES
IX. REVIEW	Slide 4-82

Review key points in the unit with PowerPoint slides. Answer any questions students have.

Question 1. Why is it important to understand hydraulic principles? — Slide 4-83

Possible Answers:

- **Ensure proper amount of water is delivered to the nozzle.**
- **Determine appropriate equipment for the job.**
- **Troubleshoot problems with the water delivery system.**
- **Reduce damage to equipment.**

Question 2. The hose lay has 500′ of 1½″ hose, and one Forester nozzle with a 3/8″ tip is attached. The nozzle is 30′ above the pump. — Slide 4-84

a) What is flow?

Answer: 30 gpm

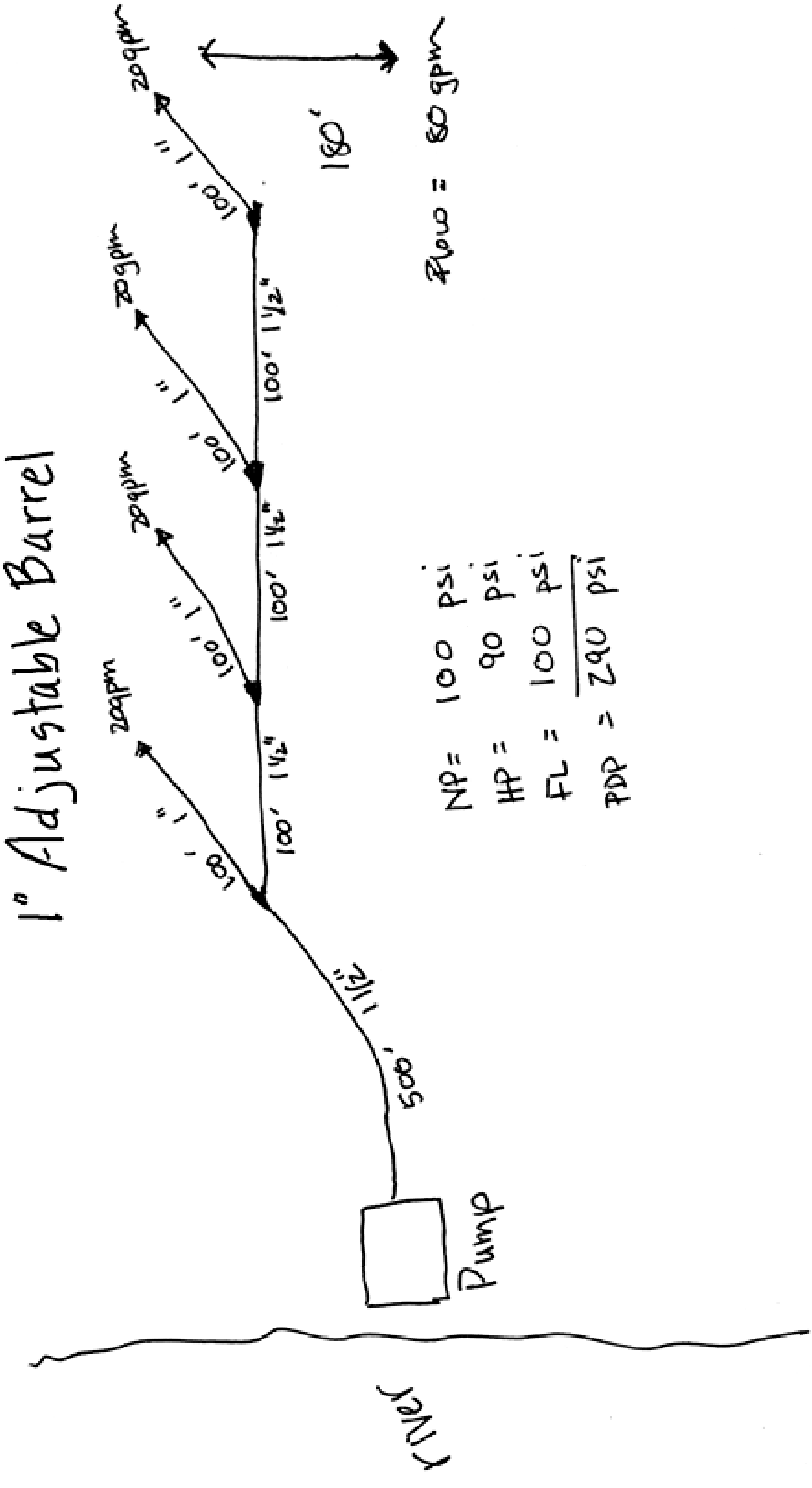
b) What is PDP?

Answer:

NP = 50 psi
HP = + 15 psi
FL = 15 psi
PDP = 80 psi

OUTLINE	AIDS & CUES
c) Identify pumps capable of providing flow and PDP.	
Answer: Mark 3 and Wick 375	
Question 3. What is the definition of pump discharge pressure (PDP)? Where is pump discharge pressure measured?	Slide 4-85
Answer: PDP is the pressure required to deliver a specific pressure and flow at the nozzle. PDP is measured at the pump panel.	
Question 4. When the nozzle is located uphill from the pump, do you subtract or add head pressure in the PDP formula?	Slide 4-86
Answer: Add	
Question 5. When hose diameter increases, does friction loss increase or decrease?	Slide 4-87
Answer: Decrease	
Question 6. When flow (gpm) decreases, does friction loss increase or decrease?	Slide 4-88
Answer: Decrease	
Question 7. Do longer hose lengths have more or less friction loss than shorter hose lengths (of same diameter)?	Slide 4-89
Answer: More	

OUTLINE	AIDS & CUES
Question 8. If there is significant elevation rise from the pump to the nozzle and one pump cannot provide the pressure that is needed, which multiple pump system would most likely solve the problem – series pumping or parallel pumping? **Answer: Series pumping**	Slide 4-90
Question 9. You are filling a drop tank, and it is going slow. You want to increase the flow to speed it up. What pump configuration would you use – series pumping or parallel pumping? **Answer: Parallel pumping**	Slide 4-91
Question 10. What impact do parallel lines have on friction loss – increase friction loss or decrease friction loss? **Answer: Decrease**	Slide 4-92
Question 11. Friction loss needs to be reduced. What options should be considered? **Possible Answers:** • **Increase hose diameter.** • **Shorten hose length.** • **Use a parallel hose lay.** • **Reduce flow.**	Slide 4-93
Review Unit Objectives. **Administer Classroom Final Exam.** **Present instructions for Field Exercise (Unit 5).**	Slide 4-94 Slide 4-95


1" Adjustable Barrel
20gpm
100' 1"
100' 1½"
20gpm
100' 1"
100' 1½"
20gpm
100' 1"
100' 1½"
20gpm
100' 1"
180'
500' 1½"
Pump
river
NP = 100 psi
HP = 90 psi
FL = 100 psi
PDP = 290 psi
Flow = 80 gpm

UNIT OVERVIEW

Course Portable Pumps and Water Use, S-211

Unit 5 – Field Exercise

Time 4–8 Hours

Objectives

1. Participate in portable water delivery system set up, operation, troubleshooting, and shut down.
2. Demonstrate appropriate risk management activities, such as wearing PPE (including ear and eye protection as appropriate) and fuel handling procedures.

Strategy

This unit is taught in the field, so advanced preparation is required. The field exercise is designed so the cadre has flexibility to tailor it to their own needs. Instructors will demonstrate proper techniques, and then students will practice.

Instructional Method

- Demonstration and Practice

Materials Needed – Instructors

- ☐ Personal Protective Equipment (PPE), including eye and ear protection
- ☐ Incident Response Pocket Guide (IRPG)
- ☐ Portable Pump Kits and additional equipment for setting up pumps (shovel, fuel, etc.) (1 per small group or as needed)
- ☐ Hoses, nozzles, and appliances for setting up portable water delivery system (1 set per small group or as needed)
- ☐ Optional: Sprinkler kit and other types of portable pumps (1 per small group or as needed)
- ☐ Optional: Pump pressure gauges

Materials Needed – Students

- ☐ PPE, including eye and ear protection
- ☐ IRPG
- ☐ Student Workbook

Exercise

- Field Exercise

Evaluation Method

- Objectives will be tested in Field Exercise Final Exam.

Outline

None

Aids and Cues Codes

The codes in the Aids and Cues column are defined as follows:

IG – Instructor Guide	IR – Instructor Reference
SW – Student Workbook	SR – Student Reference
HO – Handout	Slide – PowerPoint

EXERCISE: Field Exercise

Purpose: The purpose of the field exercise is to provide students experience with participating in setup, operation, troubleshooting, and shutdown of a portable water delivery system and demonstrating appropriate risk management activities. Students will be evaluated by instructors during the field exercise (30 points).

Time: 8 hours

Exercise Preparation:

1. Tailor the field exercise to meet the needs of the local area.

2. Allow plenty of time to plan and set up the field exercise.

3. The field exercise must address the following:

    - Local protocol
        - Environmental concerns
        - Equipment (pumps, hose packs)
    - Pump setup
        - Placement of berm(s), pads, and fuel can
        - Fuel mixing and refueling
    - Pump operations
        - Startup
        - Operate
        - Shutdown (draining pump head)

- Troubleshooting
  - Flooding
  - Loss of prime
- Hose lay and nozzle operation

Additional items to consider including in the field exercise:

- Multiple pump setup
  - Hydraulics application
  - Series
  - Parallel

4. Determine how to organize field day. There are numerous methods to consider; some examples include:

   - Learning stations are an excellent way to teach students. They usually require an instructor for each learning station, but not always. Students are assigned to small groups, and each group rotates through the station. There are numerous examples of how learning stations can be set up, for example:
     - Station for each type of pump (i.e., high pressure portable pump, volume pumping, sprinklers, multiple pumps) – at each station students set up, operate, troubleshoot, and shut down the pump.
     - Station for key steps in operating a pump (i.e., setup, starting and operating, troubleshooting, and shutdown).
     - Station for each key component of the water delivery system (i.e., designing a water delivery system, operating a pump, setting up hose lay, setting up multiple pumping systems).

- Simulating an incident is another excellent way to set up a field exercise; however, it does require more planning, coordination, and resources. Flag critical features (e.g., river, hill, road, fire) of the incident. Simulation can start with a briefing from the Incident Commander or crew boss – in the briefing, the students are instructed on what to do.

- Consider incorporating fun competition into the exercise; for example, groups can critique each other's setup, or one group can create a problem and the other team has to troubleshoot.

5. Make logistical arrangements, such as:

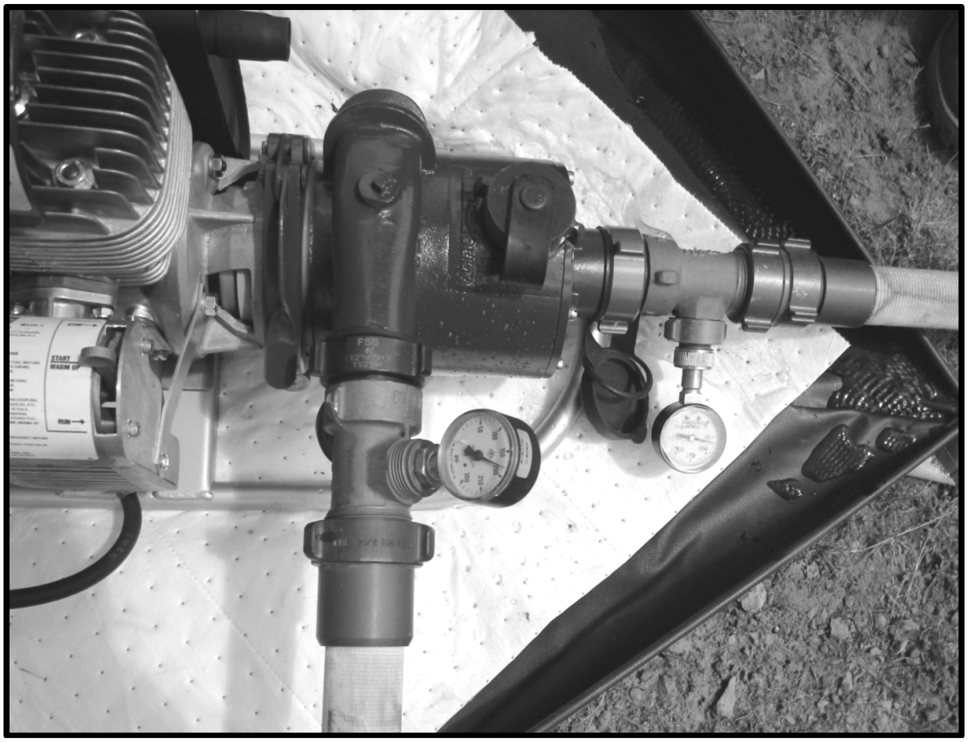
   - Find appropriate site for field exercise (transportation time to and from site, water supply source, environmental considerations, and so on).

   - Obtain all equipment and supplies.

   - Transportation to and from site.

6. Review the Field Exercise Final Exam (Appendix D), and determine how the cadre will conduct the evaluation. For example, will each instructor be assigned specific students to evaluate, or will the cadre (as a group) evaluate students? Please note that students are only being evaluated on risk management activities and participation in the field exercise. There is no answer key for the Field Exercise Final Exam.

7. Consider using pump pressure gauges to help students understand how pressure changes. The gauge is very effective with demonstrating the difference in how series pumping and parallel pumping impact pressure.



Exercise Instructions:

1. One day before administration of field exercise, present general overview of field exercise so students can be prepared. This overview should address:

   - Schedule and logistics

   - What students should bring – wear full PPE, IRPG, Student Workbook

   - Review objectives with students:

     – Demonstrate appropriate risk management activities, such as wearing PPE (including ear and eye protection as appropriate).

     – Participate in portable water delivery system setup, operation, troubleshooting, and shutdown.

2. Discuss evaluation method. Refer students to their Student Workbook (SW, page 5.3), and discuss criteria and total points for the field exercise.

3. Divide students into small groups, and give directions on where they should go.

4. Instructors should demonstrate proper procedures, and then allow students to practice.

5. When exercise is completed, instructors should conduct an After Action Review (AAR) before evaluating students.

6. Instructors evaluate students, enter points on Field Exercise Final Exam, determine total score on final exams (Classroom Final Exam plus Field Exercise Final Exam), and return exams to students.

End of Exercise.