

**DUAL UNIT INVESTIGATION
FOR
HIGHWAYS IN THE RIVER ENVIRONMENT**

NHI COURSE NO. 13010

Prepared for

**Federal Highway Administration/National Highway Institute
under
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1. INTRODUCTION

Ayres Associates was given the task of identifying and evaluating alternate methods for incorporating English and SI units into the Reference/Design Manual and Instructor's Guide for the "Highways in the River Environment" (HIRE) publication. Realistically, the format chosen could set the pattern for all future FHWA hydraulic related publications and NHI courses.

In April 1999, AASHTO reported on the results of a questionnaire on state usage of the Metric System at an SCOH meeting in Little Rock, Arkansas. State representatives were asked their current status regarding use or planned use of the Metric (SI) System. Of the 42 states (including Washington, D.C. and Puerto Rico) responding, 21 are currently using and plan to continue to use SI. The remaining 21 states either have not and do not plan to convert from English to SI or have current plans to convert back to English.

The current status of metric conversion for FHWA is reflected in two documents available on the World Wide Web: (1) FHWA Memorandum - "Metric Conversion at State Option," dated October 22, 1998, and (2) FHWA Metric Briefing - "Metric Conversion of the Federal-Aid Highway Program, dated November 4, 1998. These two documents are enclosed for reference as Appendices 1 and 2, respectively. The following figure from a recent article in CE News ("The Long and the Short of Metric Conversion," July 1999, pp. 42-43) shows the approximate distribution of metric and non-metric states as of March 1999.



Metric Figure.

2. SCOPE

The scope of the Task Assignment included identifying and evaluating alternative methods for incorporating SI and English units into the Reference Manual and Instructor's Guide when developing these items for the course 13010 - Highways in the River Environment. The evaluation included: cost, ease of use in the classroom, distribution, and stand-alone use of the Reference Manual in either SI or English units. This study identifies a preferred alternative and lists the reasons for recommending this alternative. The term "English units" represents the historic English units or "Customary U.S. Units" of feet, pounds, etc.

3. IDENTIFICATION OF ALTERNATIVES

In establishing various alternatives for both reference manuals and NHI course materials, the primary concern for the manuals and course materials should be to meet the needs of the customer regarding the ease of use of the manuals, not necessarily the economics of their development or distribution. Therefore, the following criteria should be met by any alternative considered.

- No "soft conversions" should be used for charts, figures, nomographs, etc.
- Charts should be developed for both sets of units regardless of how the manuals and courses are developed.
- Nomographs should be eliminated if simple equations can be substituted.

3.1 Design Manuals

Alternatives for design/reference manuals could be:

1. Separate independent manuals in SI and English Units with appropriate charts, etc.
2. Manuals with dual units with English units as primary.
 - All equations would have a constant for both units
 - Charts, etc. would be provided for English units in the text
 - Example problems would be worked only in English units
 - SI charts and example problems in Appendix
3. Manuals with dual units with SI units as primary.
 - All equations would have a constant for both units
 - Charts, etc. would be provided for SI units in the text
 - Example problems would be worked only in SI units
 - English charts and example problems in Appendix
4. Manual in dual units with English charts and problems and a separate Supplement with SI charts and problems.
5. Manual in dual units with SI charts and problems and a separate Supplement with English charts and problems.

3.2 NHI Course Material

Alternatives for the NHI course material could be one of the following:

1. Separate Participant Workbooks for English and SI units. The two courses would have different numbers in order to reduce confusion.
2. One course with one dual unit Participant Workbook and two separate Problem Workbooks (one English and one SI).
3. Participant Workbook in English with a Supplement for workshops in SI.
4. Participant Workbook in SI with a Supplement for workshops in English.

4. EVALUATION OF ALTERNATIVES

In evaluating the above alternatives, it was recognized that input from the "customers" (future users of the reference manuals and NHI course materials) would be helpful. Although a survey of the "customer" was not part of the original scope of the study, an informal survey of the State hydraulic engineers' preferences of the above alternatives was made in late June and early July 1999. (Attachment A is a copy of the survey that was faxed to the States.) Cost, ease of use in classroom, ease of distribution, and use of the Reference Manual are also considered in the evaluation.

In addition to the survey, the recent updating of the *Urban Drainage Course* and a pilot course scheduled for mid-July offered the opportunity to evaluate one of the course material alternatives and apply lessons learned to this Task Assignment.

5. SUMMARY OF DUAL UNITS SURVEY

Forty surveys were returned from state highway agencies. The attached summaries of replies with appropriate graphs are provided in attachments B and C. Everyone did not respond to each question. Therefore, there will not always be 40 responses for every item.

5.1 General Comments

Not everyone responded to the general comments. However, the following summary is provided for those who commented.

- | | | |
|---|-----------|-------------|
| 1. No "soft conversions" ... | 24 agreed | 2 disagreed |
| 2. Charts for both units be developed ... | 25 agreed | 2 disagreed |
| 3. Nomographs be eliminated ... | 24 agreed | 6 disagreed |

5.2 Design Manuals

First Choices

- 50 percent of those who replied preferred separate manuals
- 27.5 percent preferred dual units with English as primary with a SI appendix
- 12.5 percent preferred dual units with SI as primary with an English appendix
- The choice of dual units with either SI or English Supplements was essentially ignored (only 3 voted for English charts with a SI Supplement and 1 for the SI Charts with an English Supplement)

Weighted Results

In an attempt to also take second and third choices into consideration, assigned values of 5 points for first choice, 4 points for second choice, etc., were made. The following values are noted.

1. Separate Manuals	149 points
2. Dual Units, English Primary, SI Appendix	131 points
3. Dual Units, SI Primary, English Appendix	100 points
4. Dual Units, English Charts and Problems with SI Supplement	98 points
5. Dual Units, SI Charts and Problems with English Supplement	73 points

Although the order of ranking did not change and the separate manuals again were first, the difference between the first and second choice is not as great. Furthermore, there is little difference between the third and fourth choice. Again, choice number 5 does not appear to be one for consideration by the States.

5.3 NHI Course Material

First Choices

- 40 percent of replies preferred separate workbooks and courses
- 32.5 percent preferred dual unit workbooks with separate problem workbooks in SI and English Units.
- 15 percent wanted workbook in English and a SI workshop supplement
- 10 percent preferred workbook in SI and workshop supplement in English

Weighted Results

A weighted summary was also made assigning 4 for first place, 3 for second, etc. The following is the summary of the weighted results.

1. Separate workbooks with two courses	113 points
--	------------

- | | |
|---|-----------|
| 2. Dual unit participant workbooks with separate problem workbooks... | 98 points |
| 3. Workbooks in English with SI supplement | 88 points |
| 4. Workbook in SI units with English supplement | 62 points |

Again the ranking did not change, but the difference between choices 1 and 2 is not as great. The workbook in SI units with English supplement is not popular.

5.4 Comments

In addition to the above choices, comments were solicited from the States. A list of all the comments given follows:

Alaska recommends eliminating nomographs for more complex equations and use spreadsheets.

Arizona suggests all options be placed on the Internet so the user can choose his units.

California agrees with all three general items. Given current use of computers and software, nomographs are much less frequently used or needed.

Delaware suggests not producing metric manuals until Federal Government commitment is made to go metric.

Maine wants to keep nomographs.

Michigan recommends keeping culvert nomographs.

Mississippi prefers courses be provided with emphasis on English units. If work must continue to be done in SI, then training could still be provided in one course. Once understanding of the background is obtained, the units should not be a problem.

Missouri - nomographs are still useful for quick estimates. They are switching back to English units with SI in parenthesis.

Nebraska wants nomographs and simple equations.

New Mexico wants both equations and nomographs.

North Carolina would like to retain the nomographs for English version. They are a very good tool for quick and visual comparison of alternatives. Recommends only develop English manuals and provide a supplement document (not an independent manual) that includes appropriate SI units, charts, etc. This supplemental document would follow the English unit manual chapter and section format to facilitate cross-reference.

Puerto Rico says using simple equations instead of nomographs is a great idea.

South Carolina - Although most DOT's are going back to English, we should not close the door on SI. Dual units should be given with primary being English.

South Dakota agrees to eliminate nomographs. Nomographs have less value today for most design applications are completed with the use of computer software.

Virginia - use English units.

6. URBAN DRAINAGE PILOT COURSE: NHI 13027

An additional resource for evaluation of the alternatives was the recent updating of the NHI *Urban Drainage Course* and a pilot course using the new material. Although the *Urban Drainage Course* was not part of the scope of the study, the format used in the course and lessons learned from the July 13 -15, 1999, pilot session of the NHI Course 13027, *Urban Drainage Design*, held in Lawrence, Kansas provide guidance on evaluating the choices for the development of the *HIRE Course* material.

6.1 Course Format

The *Urban Drainage Course* was developed with the following format:

Reference Manual had been previously developed and has dual units with SI units primary and English units secondary. Example problems are worked in SI units with "givens" and "answers" also in English units. All equations have a constant that is provided in both SI and English units. Figures, graphs, and nomographs are only in SI units.

Course Presentations were developed with both units on the slides and appropriate overheads. Visuals for general discussion were unit neutral wherever practical.

Participant Manual was also developed with dual units with SI primary and English secondary.

Problem Manual was developed in single units. Since the pilot course was presented in SI units, the problem manual used at the pilot course was only in SI units. It was intended that there would be one problem manual for SI units and one for English units. Separate visual aids such as overheads of graphs, charts, etc. used in problem sessions will be developed for both units.

6.2 Lessons Learned from *Urban Drainage Course*

In preparing the participants' manual and problems in dual units, it became apparent that giving two "givens" and "solutions" with appropriate design guides (charts and graphs) concurrently in the same manual would be unwieldy and difficult to use. This was due in part to the use of a comprehensive design problem, where the results of one workshop were necessary for the next workshop. Locating the answers for a previous workshop was awkward when the dual unit presentations and all the basic lesson material were in a single document. Furthermore, the electronic files with all the charts, graphs, etc., became very large and hard to manage. To resolve these issues, the problems were taken out of the participants' manual, and three separate manuals were developed. The participants' manual was prepared in dual units, and separate problem manuals with appropriate design guides

(charts, nomographs, etc.) were prepared for each set of units. For this course, the SI problem manual was provided to the participants.

This format worked well in the pilot course. The only problem that became apparent from this process was that many of the participants at the course were from local cities and counties that had not switched from English units to SI units. These participants preferred design guides in English units. Therefore, consideration should be made to provide both problem manuals in future courses.

7. REVIEW OF COST, EASE OF USE, AND DISTRIBUTION

7.1 Costs

In discussions with NHI, the cost of printing is very reasonable. From recent figures, printing cost is approximately 1.3 cents per page. Thus, printing cost of another manual is insignificant in comparison of other costs associated with a training course such as salaries, travel costs, etc. Therefore, the ease of use, ease of distribution, etc. should be the primary consideration in selecting the Reference Manual and NHI course material formats.

7.2 Ease of Use

Reference manuals with a single unit might be easier to use than one with dual units, particularly when there are numerous design charts and figures that must be of only one unit. However, a dual unit manual would not be that much more difficult to use. In some States where the local governments use one set of units and the State another, one manual would be beneficial when engineers from each entity might confer with one another: i.e., one manual, same page numbers, same equation numbers, etc.

For NHI course materials, separate single unit reference manuals and corresponding participants' manuals would be easy to use. Problems could be included in the participants' manual. In contrast, dual unit manuals would not be difficult to use either. In States where local entities attend the NHI courses, dual unit manuals would be more useful for them since they may not be using the same units as the State.

7.3 Ease of Distribution

For reference manuals with single units, the FHWA would have to make distribution of two separate manuals and keep a current list of which State has which units or make a double distribution (one of each unit) to each State. One could foresee problems in sending the correct manual to the right State and/or locality. Dual units reference manuals would follow current distribution procedures and meet the needs of all entities.

For NHI courses, the problem of being sure that the materials with the correct units are sent to the right course will exist. Furthermore, when a course is held in a State where local entities are present, requests for both manuals will probably be made. Thus, distribution of manuals with separate units would be more challenging than distributing manuals with dual units. With dual unit manuals, the existing distribution process would work.

7.4 Evaluation Summary

In general, the following points may be summarized from evaluating the various alternatives using the survey results and experience from the *Urban Drainage Course*:

- Ease of use and satisfying the desires of the States' engineers should be the primary concern in choosing the alternatives to use in future manual and course development or update.
- Stocking of manuals and ease of distribution should also be a concern.
- The printing cost of reference manuals and NHI course material does not appear to be of major concern.
- As illustrated in the survey results, almost everyone agrees that:
 - No "soft conversions" be used for charts, figures, etc.
 - Charts should be developed for both sets of units regardless of how the manuals and courses are developed.
 - Equations be used instead of nomographs. This item did receive more negative votes than the previous two recommendations. However 24 agreed with this concept and only 6 disagreed. From the comments received, it appeared that most of the concern was directed toward the culvert nomographs. Since nomographs are already available for both sets of units for culverts, they could be retained. Furthermore, there are no "simple" equations for the culvert inlet control curves. Therefore, nomographs or computer solutions are the only practical solution for the culvert problem.
- For reference manuals, separate manuals received most votes in the survey. However, the weighted results placed the dual units with English units primary with a SI appendix a close second.
- For NHI course material, separate unit workbooks were first in the survey with dual units participants' manuals with separate unit workbooks a close second. In fact, the weighted results showed little difference between these two choices.

8. GENERAL RECOMMENDATIONS

After reviewing the results of the survey and the lessons learned in updating the *Urban Drainage Course*, the following general recommendations are made:

- **Reference manuals should be developed with dual units using English as the primary unit and an appendix with SI units.** When considering the problems that would result from having to keep two separate reference manuals current, stocked, and ensuring shipping of the correct version to the right State, it is reasonable to have only one document. It would also meet the needs of courses and locations where both sets of units are used.

- **English should be used as the primary unit.** At least half of the state DOTs use or plan to return to English units and the majority of the survey respondents and essentially all local governments still use English units. If reference manuals are developed only in SI units, the majority of the users would not have their needs met, particularly when the local governments are taken into consideration.
- **Presentation material (slides, etc.) and participants' manuals for NHI courses should be as unit free as possible but have dual units when units are required.** When example problems are used in the course, two problem workbooks (one for each unit) should be provided. To simplify distribution requirements, the English and SI problem workbooks could be bound together. This would also satisfy the needs of "English Users," e.g., city/county engineers who attend a course in a state where the DOT is "metric."
- **Courses developed with these guidelines will meet the needs of all participants and simplify the distribution of course material.**

Note that the above recommendations are considered to be "general recommendations." There will always be exceptions to the general rule, and the final guidelines should be "fluid." There may be instances where a course would only have a few example problems that may be shown in both units within the participants' manual. In such instances, separate example problem workbooks in different units may not be required.

9. SPECIFIC RECOMMENDATIONS FOR HIRE

9.1 HIRE Reference Manual

HIRE should be developed in accordance with the above recommendations. The reference manual should have dual units with English units primary and SI units secondary. All problems in the text would be worked only in English units. Problems with appropriate charts and figures in SI units would be provided in an Appendix.

While HIRE has 226 figures and charts, many can be presented in a unit neutral format as shown in the following summary:

Chapter	Number of Figures	Unit Neutral Figures	Dual Figures
1	3	3	0
2	45	42	3
3	29	15	14
4	18	15	3
5	59	62	7
6	0	0	0
7	55	40	15
Problems	17	0	17
TOTAL	226	167	59

HIRE has 59 tables. About half of the Tables would require dual presentation as shown in the following summary

Chapter	Number of Tables	Unit Neutral Tables	Dual Tables
1	0	0	0
2	3	3	0
3	7	2	5
4	6	4	2
5	6	5	1
6	1	1	0
7	15	4	11
Problems	21	7	14
TOTAL	59	26	*33
*Four or five of the dual unit tables could be made non-dimensional			

Given this inventory, the HIRE dual unit reference manual would have approximately 540 pages with an SI Appendix of approximately 85 pages.

9.2 HIRE NHI Course Material

The HIRE participants' manual should be developed unit neutral as far as practicable, with dual units when required. A separate unit specific problem workbook would be developed including problems, charts, etc. in both English and SI units and bound into a single workbook volume.

The current edition of HIRE has 31 problems presented in 79 pages. While not all problems are used during a course presentation, all should be included in the problem workbook so that the instructor(s) can adapt the course to regional conditions or to their own experience by having a range of problems to select from.

Based on the revised course outline, the basic dual unit (or unit neutral) Participant Workbook and Instructor Guide would have 20 lessons presented in approximately 280 pages. The Problem Workbook would be approximately 160 pages in length with the first 80 pages being English problems, charts, nomographs, etc. and the second 80 pages being the same problems, charts, nomographs, etc., worked in SI.

With this recommendation, the standard course packet shipped to all states, regardless of their SI/English status, would consist of the following three items:

- HIRE Reference Manual (dual unit, English problems in text, SI problems in Appendix)
- HIRE Participant Workbook (unit neutral insofar as possible)
- HIRE Problem Workbook (English problems in first half, SI problems in second half)

APPENDIX 1

FHWA Memorandum - Metric Conversion at State Option

**FHWA Memorandum to all State Chief Executive Officers
Regarding Metrication Conversion at State Option**

To all State Chief Executive Officers:

Since the passage of the Transportation Equity Act for the 21st Century (TEA-21), there have been several inquiries concerning its impact on the Federal Highway Administration's (FHWA) metric conversion policy and progress. In TEA-21, Section 1211(d) removes the target date for metric conversion, thereby allowing the State departments of transportation (DOTs) the option of converting to the International System of Measurements (SI). Section 1211(d) reads as follows:

SEC. 1211. (d) METRIC CONVERSION AT STATE OPTION.

Section 205(c)(2) of the National Highway System Designation Act of 1995 (23 U.S.C. 109 note; 109 Stat. 577) is amended by striking "Before September 30, 2000, the" and inserting "The".

This change results in the following language:

The Secretary shall not require that any State use or plan to use the metric system with respect to designing or advertising, or preparing plans, specifications, estimates, or other documents, for a Federal-aid highway project eligible for assistance under title 23, United States Code.

In order to better understand the Congressional intent of Section 1211, we have, with the assistance of the Office of Chief Counsel, reviewed the Congressional Record and the TEA-21 conference report. The conference report clearly states that Section 1211(d) does not require any State to modify its current use of the metric system for highways. Comments in the instructions to the conferees indicate that Congress still considers SI to be the preferred system of measurements for the United States and, therefore, Congress did not anticipate that any already converted State would revert as a result of this provision.

We recognize that there are many concerns within the highway community regarding the cost of conversion to SI units and the reason for doing so. One such common comment, for example, is "Why do we need to convert to metric in this country when we do not export highways." The United States however, does export the expertise, technology, and products to construct highways efficiently. In order to do so effectively, we must operate within the global system of measurements. The United States and Myanmar (formerly known as Burma) are the only countries globally which continue to operate predominately in inch-pound units. Companies desiring to compete in the global marketplace are changing to SI. Converting the Federal-aid highway program to SI will assist the highway industry in making this change. In addition, we will expedite technology transfer between national and State-level transportation agencies by moving to the global system of measurements.

Therefore, while FHWA can no longer mandate that States convert to SI, we strongly encourage its continued use. Most of the State DOTs have substantially converted their project development and construction processes to SI. Full conversion by all the State DOTs remains an FHWA goal since it will improve efficiency within the highway construction industry by reducing translation errors and enabling the contractors, consultants, fabricators and material suppliers to return to a single system of units. Recently the Construction Metrication Council (CMC) conducted case studies of 25 SI projects from around the country. The projects varied in size and complexity. Overall, the CMC found that while contractor personnel were initially resistant to SI, especially among workers over 50 years old, those

contractors that began and carried the project through in SI had few difficulties. Most of the reported metric problems were related to reverse conversion by contractor personnel. The remaining metric problems were materials supply issues which will decrease as the volume of metric construction increases. Project costs were similar to inch-pound projects of the same size and complexity.

The FHWA believes that it is in the best interest of the highway community to expedite the metrication process and ensure compatibility within the highway industry and with other industries. Reversion to inch-pound units by some States will perpetuate a confusing mix of measurement systems and lengthen the time that the highway contracting industry must operate in a dual unit environment.

Section 1211(d) does not change the requirements placed on the FHWA by Section 5164(b) of the Omnibus Trade and Competitiveness Act of 1988 (Public Law 100-418). Therefore, FHWA will continue to use SI in its daily business activities. Data collection for the Highway Performance Monitoring Program, the Truck Size and Weight Study, and the National Bridge Inventory will continue in SI. In keeping with existing policy, FHWA will use dual units with the SI value first followed by the inch-pound value in parentheses, for correspondence or publications intended for a broad audience which includes the general public (for example, right-of-way or environmental clearance documents, or general information about FHWA programs). All other FHWA documents, including research reports prepared under FHWA planning and research grants, should be in SI only.

Questions about FHWA policy on metric conversion may be referred to either Mr. David Cox (202-366-0355) or Ms. Jennifer Balis (202-366-4631).

Sincerely yours,

Original Signed by:

Kenneth R. Wykle, Federal Highway Administrator
on October 22, 1998

This page last modified on June 22, 1999



APPENDIX 2

Metric Conversion of the Federal Aid Highway Program

METRIC CONVERSION OF THE FEDERAL-AID HIGHWAY PROGRAM

November 4, 1998

Legislative Background:

The 1988 Omnibus Trade and Competitiveness Act (Public Law 100-418, signed into law 8/23/88), Section 5164(b) amended the 1975 Metric Conversion Act to require that Federal agencies use the International System of Measurements (SI) in their procurement, grants, and other business related activities. On July 25, 1991, President Bush signed Executive Order 12770 requiring that all Federal agencies develop timetables for their transition to the metric system.

Section 205(c) of the National Highway System Designation (NHS) Act of 1995 prohibited the Federal Highway Administration (FHWA) from mandating that the State Departments of Transportation (DOT) place metric legend signs, and which prohibited FHWA from mandating the use of metric units in the highway construction program before October 1, 2000.

However, the current statute, the 1998 Transportation Equity Act for the 21st Century (TEA-21), removes the target date for metric conversion, thus allowing the State DOTs the option of converting to SI (see TEA-21 Section 1211(d)). Therefore, while FHWA can no longer mandate that States convert to SI, we strongly encourage its continued use.

Status of Conversion Effort:

The FHWA Metric Conversion Plan was approved on October 31, 1991. The Metric Conversion Policy was published in the June 11, 1992 Federal Register. The plan defined a five year program for complete conversion of the Federal-aid highway construction program by September 30, 1996. The FHWA's conversion timetable was set to provide ample time for FHWA, State DOTs and industry to adjust.

After the NHS Act, the American Association of State Highway and Transportation Officials (AASHTO) Metric Clearinghouse conducted a survey of the State DOTs to find out how many would maintain the timetable they had originally established for their metric conversion program. At that time, forty-five SHAs responded that they would maintain October 1, 1996, as their internal deadline; three would delay until 1997; and four (Hawaii, the Dakotas and Rhode Island) would delay until 2000.

In a follow-up Metric Clearinghouse survey, 43 SHAs responded with information about metric conversion costs. While four states (Alabama, Florida, New Jersey and Pennsylvania) had costs more than \$5 million; fifteen states reported costs less than \$1 million and five states had not tracked their conversion costs at all. Overall metric conversion has cost the SHAs more than \$70 million with the average about \$1.6 million; and the median cost about \$1 million.

However, the optional conversion language in TEA-21 has resulted in a change in some State DOT conversion plans. In a post TEA-21 survey, AASHTO polled the State DOTs regarding their intentions to use SI units or revert back to inch-pound units. From the 46 responses received from the State DOTs, AASHTO found that 26 States will continue to use SI, 10 States will revert to inch-pound units and 10 were still considering the issue.

Nationwide, highway construction is about 65% in metric units for 1998; and 75% for 1999.

Highway Signing:

In 1995, the Battelle Institute conducted a study to quantify the costs of converting highway signs. This study collected information from 13 states, 67 counties, and 48 cities across the United States. Battelle determined that about six million signs which contain a dimension in their legend will need to be converted across the country. Battelle then estimated the nationwide costs using five different conversion schemes. The estimated costs range from \$15 million for routine replacement of all signs to \$826 million for installation dual unit sign legends.

In fiscal years 1994, 1995 and 1996, Congress prohibited the use of Federal-aid highway funds by SHAs to cover the costs of converting highway signs. There is no prohibition for fiscal year 1997.

ATTACHMENT A
State Survey

SURVEY

Use of English/Metric in FHWA Manuals and NHI Training Materials

Ayres Associates has been given the task of identifying and evaluating alternate methods for incorporating English and SI (Metric) units into the Reference Manual and training course materials for the "Highways in the River Environment. Realistically, the process chosen could well set the pattern for all future FHWA hydraulic related publications (for example, Hydraulic Engineering Circulars) and NHI courses. Therefore, input from the user of the manuals and NHI training courses is solicited. Please respond to this FAX by adding your comments in places indicated (only a few minutes is required) and return the FAX as indicated below.

General Comments

1. No "soft conversions" should be used for charts, figures, nomographs, etc.
2. Charts should be developed for both sets of units regardless of how the manuals and courses are developed.
3. Nomographs will be eliminated if simple equations can be substituted.

Your Comments on the above (agree, disagree, etc.):

Design Manuals

Please rank in order of your preference. (First choice, 2nd choice, etc., e.g., 1, 5, 4, 2, 3).

Alternatives for design manuals (e.g., Hydraulic Engineering Circulars) could be:

Preference

- _____ 1. Separate independent manuals in SI and English Units with appropriate charts, etc.
- _____ 2. Manuals with dual units with English units as primary.
- All equations would have a constant for both units
 - Charts, etc. would be provided for English units in the text
 - Example problems would be only worked in English units
 - SI charts and example problems in Appendix
- _____ 3. Manuals with dual units with SI units as primary.
- All equations would have a constant for both units
 - Charts, etc. would be provided for SI units in the text
 - Example problems would be only worked in SI units
 - English charts and example problems in Appendix

- _____ 4. Manual in dual units with English charts and problems and a separate Supplement with SI charts and problems.
- _____ 5. Manual in dual units with SI charts and problems and a separate Supplement with English charts and problems.

Additional Suggestions:

NHI Course Material

Alternatives for course development (e.g., Participant Workbook) are: (First choice, 2nd choice, etc., e.g., 4, 1, 3, 2).

Preference

- _____ 1. Separate Participant Workbooks for English and SI units. The two courses would have different numbers in order to reduce confusion.
- _____ 2. One course with one dual unit Participant Workbook and two separate Problem Workbooks (one English and one SI).
- _____ 3. Participant Workbook in English with a Supplement for workshops in SI.
- _____ 4. Participant Workbook in SI with a Supplement for workshops in English.

Additional Comments

Please give us any additional alternatives that you feel should be used.

Thank you for your time and thoughts on how future hydraulic publications and related course materials should be developed. Questions can be directed by e-mail to plagasse@ayres-fc.com or call 970-223-5556. Please respond by FAX to P.F. Lagasse at (970) 223-5578. Your early response would be appreciated. We need to compile the results of this survey no later than July 7, 1999.

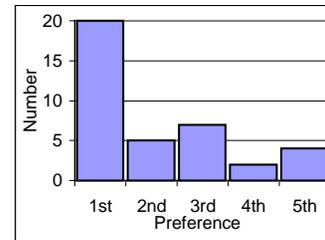


ATTACHMENT B

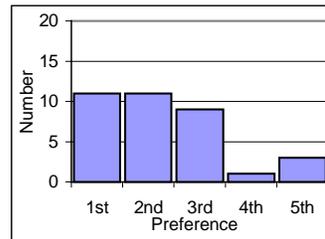
Survey Results - Design Manuals

DESIGN MANUALS	<u>1st</u>	<u>2nd</u>	<u>3rd</u>	<u>4th</u>	<u>5th</u>
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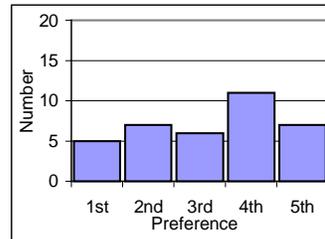
1. Separate Manuals	20	5	7	2	4
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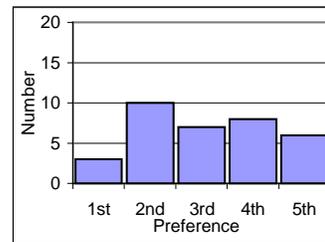
2. Dual Units, English Primary, SI Appendix	11	11	9	1	3
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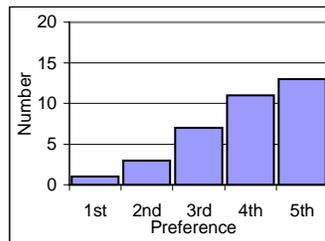
3. Dual Units, SI Primary, English Appendix	5	7	6	11	7
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4. Dual Units, English Charts and Problems, SI Supplement	3	10	7	8	6
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5. Dual Units, SI Charts and Problems, English Supplement	1	3	7	11	13
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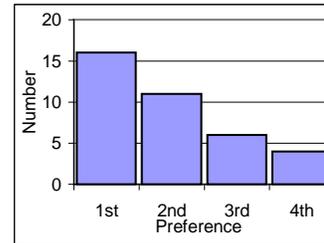




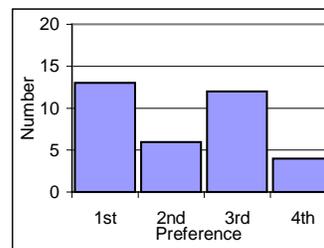
ATTACHMENT C

Survey Results - NHI Course Material

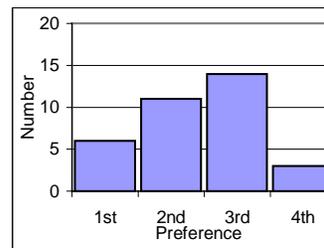
NHI COURSE MATERIAL	<u>1st</u>	<u>2nd</u>	<u>3rd</u>	<u>4th</u>
1. Separate Workbooks (Two Courses)	16	11	6	4



2. Dual Unit Participant Workbook, Separate Problem Workbooks SI and English	13	6	12	4
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3. Participant Workbook English, Workshop Supplement SI	6	11	14	3
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4. Participant Workbook SI, Workshop Supplement English	4	8	3	16
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