CHAPTER 1

SECTIONS OF A BUFR MESSAGE

1.1 Introduction. The term "message" refers to BUFR being used as a data transmission format; however, BUFR can be, and is, used in several meteorological data processing centers as an on-line storage format as well as a data archiving format.

1.2 Specifications of Octets Within Each Section. For transmission of data, each BUFR message consists of a continuous binary stream comprising 6 sections.

C O N T I N U O U S B I N A R Y S T R E A M					
section 0	section 1	section 2	section 3	section 4	section 5

Section Number	Name	Contents
0	indicator section	"BUFR" (coded according to the CCITT International Alphabet No. 5, which is functionally equivalent to ASCII), length of message, BUFR edition number.
1	identification section	length of section, identification of the message.
2	optional section	length of section and any additional items for local use by data processing centers.
3	data description section	length of section, number of data subsets, data category flag, data compression flag, and a collection of data descriptors which define the form and content of individual data elements.
4	data section	length of section and binary data.
5	end section	"7777" (coded in CCITT International Alphabet No. 5).

Each of the sections of a BUFR message is made up of a series of octets. The term octet, meaning 8 bits, was coined to avoid having to continually qualify byte as an 8-bit byte. Also, in French, the words "byte" and "bit" are pronounced the same (as "beet"), "octet" clearly avoids that problem, too.   An individual section shall always consist of an even number of octets, with extra bits added on and set to zero when necessary. Within each section, octets are numbered 1, 2, 3, etc., starting at the beginning of each section. Bit positions within octets are referred to as bit 1 to bit 8, where bit 1 is the most significant, leftmost, or high order bit. An octet with only bit 8 set would have the integer value 1.

Theoretically there is no upper limit to the size of a BUFR message but, by convention, BUFR messages are restricted to 15000 octets or 120000 bits. This limit is to allow an entire BUFR message to be contained within memory of most computers for decoding. It is also a limit set by the capabilities of the Global Telecommunications System (GTS) of the WMO. The BLOK feature, described elsewhere, can be used to break very long BUFR messages into parts, if necessary.

Figure 1-1 is an example of a complete BUFR message containing 52 octets. This particular message contains 1 temperature observation of 295.2 degrees K from WMO block/station 72491.   (Note that optional Section 2 is not included.)   Figures 1-2 through 1-7 illustrate decoding of the individual sections. The spaces between octets in Figures 1-2 through 1-7 were added to improve readability.

end of section 0

01000010010101010100011001010010000000000000000000001101000000001000000000000000

00000100100000000000000000000111000000000000000000000000000010000000000000000100000

end of section 1

00010101110100000100000111010000110000000000000000000000000000000000000000111000

0000000000000000000011000000000000001000000100000001000000100000110000000100

end of section 3   end of section 4

000000000100000000000000000001000000000001001010001111010111011100010000000001101

end of section 5

110011011100110111001101 11

Figure 1-1. Example of a complete BUFR message containing 52 octets

1-2

1.2.1 Section 0 - Indicator Section.

	CONTINUOUS BINARY STREAM				
SECTION 0	section 1	section 2	section 3	section 4	section 5

Octet No.   Contents

1 - 4   "BUFR" (coded according to the CCITT International
            Alphabet No. 5)

5 - 7   Total length of BUFR message, in octets (including
            Section 0)

  8   BUFR edition number (currently 2)

The earlier editions of BUFR did not include the total message
length in octets 5-7. Thus, in decoding BUFR Edition 0 and 1
messages, there was no way of determining the entire length of the
message without scanning ahead to find the individual lengths of
each of the sections. Edition 2 eliminates this problem by
including the total message length right up front. By design, in
BUFR Edition 2, octet 8, containing the BUFR Edition number, is in
the same octet position relative to the start of the message as it
was in Editions 0 and 1. By keeping the relative position fixed,
a decoder program can determine, at the outset, which BUFR version
was used for a particular message and then behave accordingly.
This means, for example, that archives of old (pre-Edition 2)
records need not be updated.

```
OCTET NO.          1        2        3        4        5        6        7        8

BINARY         01000010 01010101 01000110 01010010 00000000 00000000 00110100 00000010

HEXADECIMAL     4   2    5   5    4   6    5   2    0   0    0   0    3   4    0   2

DECODED            B        U        F        R                       52        2


                                        length of message in octets ─────┘        │

                                                          BUFR Edition ────────────┘
```
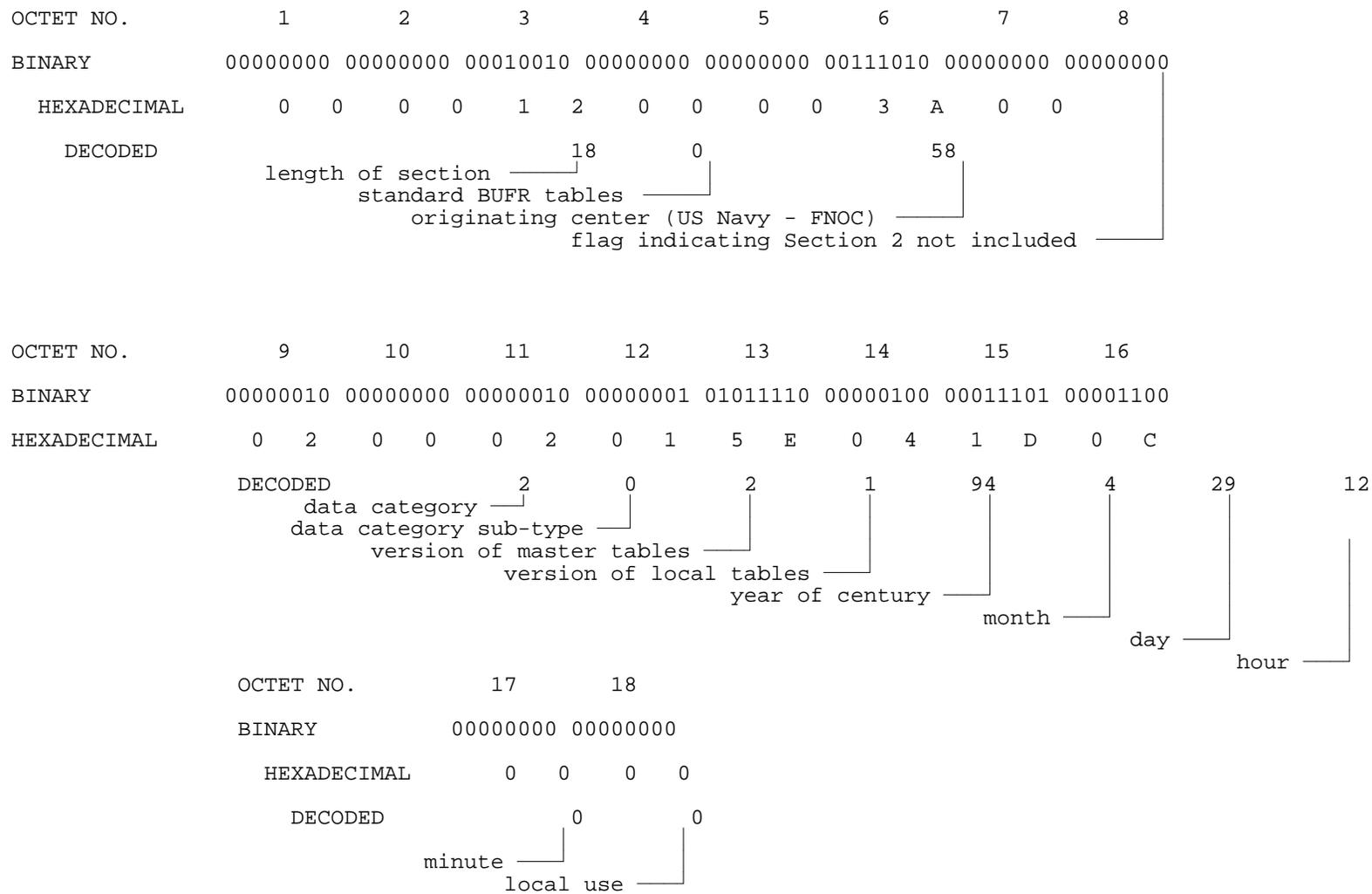
Figure 1-2. Decoding Section 0

1.2.2 Section 1 - Identification Section.

C O N T I N U O U S B I N A R Y S T R E A M					
section 0	**SECTION** **1**	section 2	section 3	section 4	section 5

Octet No.   Contents

1 - 3   Length of section, in octets

   4   BUFR master table (zero if standard WMO FM 94 BUFR
                 tables are used - provides for BUFR to be used to
                 represent data from other disciplines which may
                 have their own versions of master tables and local
                 tables)

5 - 6   Originating centre: code table 0 01 031

   7   Update sequence number (zero for original BUFR
                 messages; incremented for updates)

   8   Bit 1 = 0 no optional section
                        = 1 optional section included

                 Bits 2 - 8 set to zero (reserved)

   9   Data category type (BUFR Table A)

   10   Data category sub-type (defined by local ADP
                 centres)

   11   Version number of master tables used (currently 2
                 for WMO FM 94 BUFR tables)

   12   Version number of local tables used to augment the
                 master table in use

   13   Year of century

   14   Month

   15   Day

   16   Hour

   17   Minute

18 -   Reserved for local use by ADP centres

1-5

```
OCTET NO.          1        2        3        4        5        6        7        8

BINARY          00000000 00000000 00010010 00000000 00000000 00111010 00000000 00000000

  HEXADECIMAL     0   0    0   0    1   2    0   0    0   0    3   A    0   0

     DECODED                          18       0                 58
            length of section ─────────┘
                  standard BUFR tables ─────────┘
                    originating center (US Navy - FNOC) ─────────┘
                       flag indicating Section 2 not included ─────────┘


OCTET NO.          9       10       11       12       13       14       15       16

BINARY          00000010 00000000 00000010 00000001 01011110 00000100 00011101 00001100

HEXADECIMAL     0   2    0   0    0   2    0   1    5   E    0   4    1   D    0   C

     DECODED                 2        0        2        1        94       4       29       12
              data category ──┘
              data category sub-type ──┘
                 version of master tables ──┘
                     version of local tables ──┘
                           year of century ──┘
                                       month ──┘
                                            day ──┘
                                                hour ──┘

            OCTET NO.         17       18

            BINARY         00000000 00000000

              HEXADECIMAL    0   0    0   0

                DECODED        0        0
                      minute ──┘
                          local use ──┘
```

Figure 1-3.   Decoding Section 1

The length of Section 1 can vary between BUFR messages. Beginning
with octet 18, a data processing center may add any type of
information they choose. A decoding program may not know what that
information may be. Knowing what the length of the section is, as
indicated in octets 1-3, a decoder program can skip over the
information that begins at octet 18 and position itself at the next
section, either Section 2, if included, or Section 3. Bit 1 of
octet 8 indicates if Section 2 is included. If there is no
information beginning at octet 18, one octet must still be included
(set to 0) in order to have an even number of octets within the
section.

1.2.3 Section 2 - Optional Section.

C O N T I N U O U S B I N A R Y S T R E A M					
section	section	**SECTION**	section	section	section
0	1	**2**	3	4	5

Octet No.   Contents

1 - 3   Length of section, in octets

   4   set to zero (reserved)

5 -   Reserved for use by ADP centres

Section 2 may or may not be included in any BUFR message. When it
is contained within a BUFR message, bit 1 of octet 8, Section 1, is
set to 1. If Section 2 is not included in a message then bit 1 of
octet 8, Section 1 is set to 0. Section 2 may be used for any
purpose by an originating center. The only restrictions on the use
of Section 2 are that octets 1 - 3 are set to the length of the
section, octet 4 is set to zero and the total length of the section
contains an even number of octets.

A typical use of this optional section could be in a data base
context. The section might contain pointers into the data section
of the message, pointers which indicate the relative location of
the start of individual sets of observations (one station's worth,
for example) in the data. There could also be some sort of index
term included, such as the WMO block and station number. This
would make it quite easy to find a particular observation quickly
and avoid decoding the whole message just to find one or two
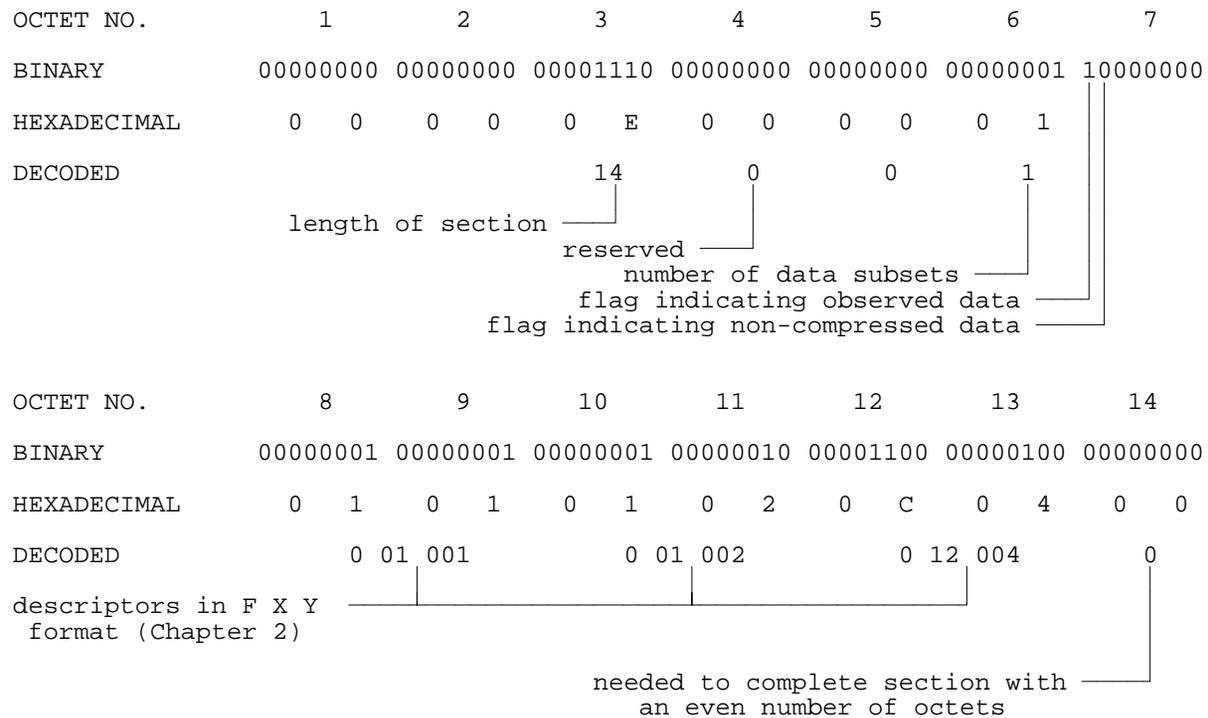specific data elements.

1.2.4 Section 3 - Data Description Section.

C O N T I N U O U S B I N A R Y S T R E A M					
section 0	section 1	section 2	**SECTION** **3**	section 4	section 5

Octet No.	Contents
1 - 3	Length of section, in octets
4	set to zero (reserved)
5 - 6	number of data subsets
7	Bit 1 = 1 observed data
	= 0 other data
	Bit 2 = 1 compressed data
	= 0 non-compressed data
	Bit 3 - 8 set to zero (reserved)
8 -	A collection of descriptors which define the form and content of the individual data elements which comprise one data subset in the data section.

If octets 5-6 indicate that there is more than one data subset in the message then multiple sets of observations, all with the same format (as described by the data descriptors) will be found in Section 4. This is a means of building "collectives" of observations. Doing so realizes a large portion of the potential of efficiency in BUFR.

In the flag bits of octet 7, "observed data" is taken to mean just that; "other data", is by custom, if not explicit statement, presumed to be forecast information, or possibly some form of "observation," indirectly derived from "true" observations. The nature of "data compression" will be described in Chapter 4.

```
OCTET NO.            1        2        3        4        5        6        7

BINARY       00000000 00000000 00001110 00000000 00000000 00000001 10000000

HEXADECIMAL    0    0    0    0    0    E    0    0    0    0    0    1

DECODED                          14        0        0        1

           length of section ─────┘
                         reserved ────────┘
                           number of data subsets ────────┘
                     flag indicating observed data ─────────────────┘
               flag indicating non-compressed data ─────────────────┘


OCTET NO.            8        9        10       11       12       13       14

BINARY       00000001 00000001 00000001 00000010 00001100 00000100 00000000

HEXADECIMAL    0    1    0    1    0    1    0    2    0    C    0    4    0    0

DECODED          0 01 001        0 01 002        0 12 004           0

descriptors in F X Y ──────┘               │               │
 format (Chapter 2)

                          needed to complete section with ─────┘
                            an even number of octets
```

Figure 1-4. Decoding Section 3

1.2.5 Section 4 - Data Section.

CONTINUOUS BINARY STREAM					
section 0	section 1	section 2	section 3	**SECTION 4**	section 5

Octet No.   Contents

1 - 3   Length of section, in octets

   4   set to zero (reserved)

   5   Binary data as defined by descriptors which begin
                at octet 8, Section 3.

1.2.6 Section 5 - End Section.

CONTINUOUS BINARY STREAM					
section 0	section 1	section 2	section 3	section 4	**SECTION 5**

Octet No.   Contents

1 - 4   "7777" (coded according to the CCITT International
                Alphabet No. 5)

   1.2.7 Required Entries. In any BUFR message there will be a
minimum number of bits to represent even the smallest amount of
data.

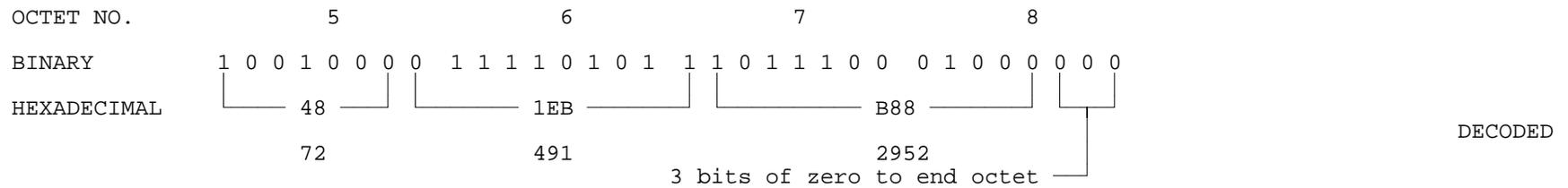| CONTINUOUS BINARY STREAM					
section 0 64 bits	section 1 144 bits	section 2 (optional)	section 3 80 bits	section 4 48 bits	section 5 32 bits

368 bits

The required entries for each section are:

     Section 0 -   octets 1 - 8
     Section 1 -   octets 1 - 18

```
OCTET NO.              1        2        3        4        5        6        7        8

BINARY            01000000 00000000 00001000 00000000 10010000 11110101 11011100 01000000

HEXADECIMAL         0   0    0   0    0   8    0   0    └─────────────────────────────────┘

DECODED                                      8        0        data as described by descriptors
                                                                    in Section 3 (Figure 1-6)
                  length of section ──────────┘
                                       reserved ───────┘
```
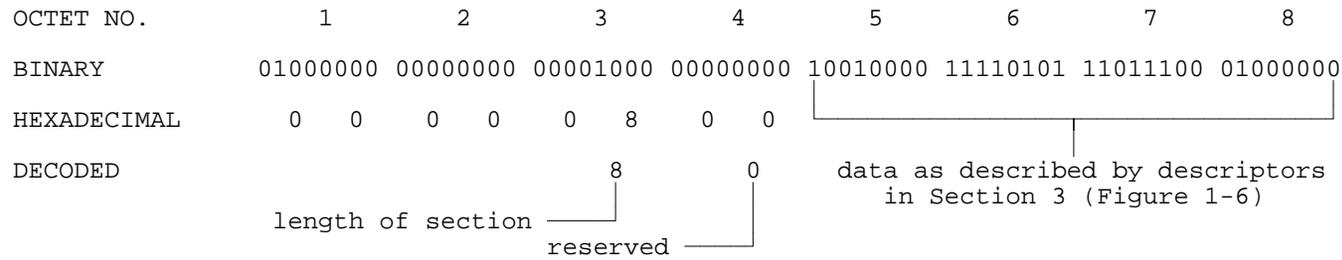
Figure 1-5. Decoding Section 4

```
OCTET NO.                  5                6                7                8

BINARY            1 0 0 1 0 0 0 0  1 1 1 1 0 1 0 1  1 1 0 1 1 1 0 0  0 1 0 0 0 0 0 0

HEXADECIMAL       └──── 48 ────┘ └───── 1EB ─────┘ └───── B88 ─────┘     └─┘

                        72             491              2952              DECODED
                                               3 bits of zero to end octet ──┘
```

Figure 1-6. Section 4 data as described by descriptors

Section 2 -   optional, but if included, octets 1 - 4 are
                required with any information to begin in
                octet 5.

Section 3 -   octets 1 - 7 The data descriptors begin in
                octet 8. A single data descriptor occupies 16
                bits, or 2 octets. Since the section must
                contain an even number of octets, there will
                be a minimum of 10 octets in the section 3.
                Section 3 will always conclude with 8 bits set
                to zero since all descriptors are 16 bits in
                length and the first descriptor begins in
                octet 8.

Section 4 -   octets 1 - 4 The data begins in octet 5.
                Since the section must contain an even number
                of octets there must be at least 2 octets after
                octet 4.

Section 5 -   octets 1 - 4

Figure 1-8 is the same BUFR message as in Figures 1-1 to 1-7. The
shaded areas in Figure 1-8 are those octets which are required in
any BUFR message. Not included in the shaded areas are descriptors
contained in octets 8 - 14 of Section 3 and the data in octets 5 -
8 of Section 4.

    1.2.8 BUFR and Data Management. Sections 3 and 4 of BUFR
contain all of the information necessary for defining and repre-
senting data. The remaining sections are defined and included
purely as aids to data management. Since key information for data
management is available from fixed locations relative to the start
of each section, it is possible to categorize and classify the main
attributes of BUFR data without decoding the data description in
Section 3 and the data in Section 4.

```
OCTET NO.               1          2          3          4

BINARY           00110111  00110111  00110111  00110111

HEXADECIMAL       3    7    3    7    3    7    3    7

DECODED              7          7          7          7
```

Figure 1-7. Decoding Section 5


```
                                          end of section 0 ──┐
010000100010101010100011001010010000000000000000110100000000100

00000000000000000010010000000000000000000111000000000000000000000

0000100000000000000100000000101011010000010000011101000001100000
```

```
        ┌── end of section 1
0000000000000000000000000000000011100000000000000000000000011000
```

```
                                    end of section 3 ──┐
0000000000100000010000000100000010000011000000100000000001000
     8       9      10      11      12      13      14
     └───────────────────── octets ───────────────────┘
```

```
                                  end of section 4 ──┐
00000000000000010000000000010010000111101011101110001000000001101
         5       6       7       8
         └──────────── octets ───────┘
```

```
     end of section 5 ──┐
11001101110011011100110111
```

Figure 1-8. Required entries in sample BUFR message