

Design and Production of Map Symbol Library Based on ArcGIS

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Abstract

In order to solve the problem that ArcGIS cannot meet the demand for China's map symbols, the required map symbols are created based on the style manager in ArcGIS and combined with Font Creator, a font editor, and AutoCAD, a drawing software, according to the 2017 version of the national standard topographic map pattern of China. This paper mainly discussed the idea of making map symbol library and the method of making marker, line and fill symbols, and established a unified coded map symbol library. The required map symbols were accurately drawn by AutoCAD to meet the accuracy requirements; the vector graphic font symbols were produced by FontCreator with the advantages of small storage space and clear symbol graphics. After installing the font files, they can be called by ArcGIS for the convenience of cartographers, which promotes the standardization of map symbols and solves problems such as map symbol differences in GIS software.

Keywords

Map Symbol; Style Manager; ArcGIS; AutoCAD; FontCreator.

1. INTRODUCTION

A map is a carrier of geographic information, and map symbols are a language for graphical representation of maps. The map symbol library is a very important component of the Geography Information System (GIS) and is a collection system of map symbols. The standardized map symbols and the easy-to-use map symbol library play an important role in the representation of maps.

With the application and development of computer technology, the form of maps has transformed from paper maps to digital maps. The techniques and methods of making, storing and applying map symbols using computers are also developing, and many units have conducted research on map symbols, and various GIS have their own map symbol libraries and cartographic standards. At present, the mapping tool software and GIS software commonly used in China contain part of the map symbols, but due to the different symbol schema standards adopted by each GIS software system, the map symbols are not compatible with each other because of the variability in many aspects such as type, shape, quantity, quality, size, and style [1-3]. ArcGIS is a very powerful and widely used geographic information software, but the map symbol library provided by it is far from meeting the needs of actual mapping work, so there is a need to establish a symbol library that conforms to China's standards.

In this study, according to China's "GB/T 20257.1-2017 National Basic Scale Map Style Part 1: 1:500 1:1000 1:2000 Topographic Map Style" [4] (hereinafter referred to as the national standard topographic map style), map symbols were accurately drawn through AutoCAD,

exported to TrueType font symbols through FontCreator, and classify and manage them in ArcGIS.

2. MATERIALS AND METHODS

2.1. Map Symbols

Map symbols, also known as the language of maps, are used by human beings to depict the objective real world with some pictographic symbols. By interconnecting geographic things and geographic phenomena in the real world with map symbols, human beings can obtain information and understand the objective world, which plays an important role in guiding human production and life practice. Map symbols have two functions: “writing” and “reading”, where “writing” and “reading” are reflected in the process of map preparation and printing, and in the process of map information acquisition by users, respectively. Geographical things and geographical phenomena in the objective real world are intricate and complex. People generalize (classify and grade), abstract and simplify them according to the needs of production and life practice [5], and use relatively simple symbols to represent them vividly, which not only reflects the distribution of things, but also solves the difficulties of depicting the real world, is intuitive and easy to read, and has an important influence on human decision-making and cognition. Map symbols express geographic information content in a visual way, which is more visual and intuitive compared with text and algorithmic language. Map symbols can represent the quantity and quality characteristics of mapping objects and their development and changes, and also show the spatial distribution of mapping objects. The map symbols of high quality can not only express the rich map content concisely and vividly, but also increase the readability of the map and facilitate the compilation and printing of the map.

2.2. Classification of map symbols

According to the characteristics and related properties of map symbols, there are various ways to classify map symbols, and two common ways are introduced below.

2.2.1 Classification by the spatial distribution of the symbols

A geographic object may be represented as different geometric symbols in different scale topographic maps, or it may be shown in one topographic map and not in another.

Marker symbols (Point symbols): represent independent point-like geographic objects or small-area geographic objects that are not represented according to the scale [6]. The size and area of the marker symbols don't represent the actual size and area of the mapping object, but the location of the symbols represents the actual geographical location of the mapping object.

Line symbols: represent geographic objects that are spatially distributed along a certain direction in the form of lines or strips [7]. Line symbols are directional and related to the map scale, with a positioning line representing the actual geographical location of the mapping object.

Fill symbols (Faceted symbols): represent geographic things or geographic phenomena that are continuously distributed in space in a faceted form [8]. The shape of the fill symbols is consistent with the actual shape of the cartographic object they represent, and their size is closely related to the scale of the map.

2.2.2 Classification by the relationship between symbols and map scale

Map symbols representing the same feature in different scale topographic maps will change with the scale. As the map scale decreases, some proportional symbols will change to partial proportional or non-proportional symbols, such as rivers.

Non-proportional symbols: Map symbols whose length and width do not follow the scale, mostly in the form of marker symbols. These symbols cannot maintain the outline of the actual

cartographic object, and cannot represent its actual area, size and height data, but can only indicate the location and meaning of geographical things.

Partial proportional symbols: Map symbols whose lengths are expressed on a scale but whose widths cannot be expressed on a scale, mostly in the form of line symbols. If the real mapping object is a narrow linear feature, which is expressed generally by partial proportional symbols, whose actual spatial location and length dimension information can be accurately expressed.

Proportional symbols: Map symbols whose length and width are expressed according to the scale, mostly expressed as fill symbols. The size and shape of the symbols change with the scale of the map, and after scaling, they can still maintain the same outline as the actual mapping object and can accurately and clearly express the spatial location of the mapping object.

3. DESIGN AND PRODUCTION OF SYMBOL LIBRARY

3.1. Management mechanism of ArcGIS graphic symbols

ArcGIS is a professional GIS software developed by ESRI, with powerful symbol graphic editing functions, symbol management and production by Style Manager to achieve.

The Style Manager, an interactive symbol design system, can create, add, delete and edit symbol libraries, and can create and manage multiple map symbol libraries at the same time without interfering with each other. ArcMap's symbol libraries are files with the suffix style, and the system automatically distinguishes various symbol types and forms several empty sub-symbol libraries of different types. A style file includes 22 sub-symbol libraries such as marker symbols, line symbols, fill symbols, etc. When creating a new symbol, select the corresponding sub-symbol library to create the symbol.

There are four ways to use ArcMap to make map symbols. Firstly, some map symbols that conform to China's cartographic standards can be added to the newly established map symbol library. Secondly, some map symbols that are similar to China's cartographic standards can be added after editing and modifying them. Thirdly, some simple geometric figures and line segments that come with the system can be combined, offset, modified and other operations using editing tools. Fourthly, it is impossible to use the existing symbol library of ArcMap directly to complete the production of China's standard map specification symbols, which needs to be completed with the help of other software. Due to the troublesome and slow process of finding and modifying the first two ways, this paper mainly adopts the fourth way to make map symbols, and the third way is supplementary.

3.2. The idea of symbol library production

Although the three symbols of marker, line and fill symbols have different characteristics and meanings, they are interrelated. The line symbols contain the marker symbols, and the fill symbols are basically filled by the marker and line symbols except for the color fill. It can be seen that the map symbol system is based on marker symbols.

There are four ways to create two-dimensional map symbol libraries in ArcGIS: (1) making a symbol library based on existing symbols in ArcGIS; (2) making a symbol library based on images; (3) making a symbol library based on TrueType fonts; (4) making a symbol library using a combination of the above. The first method can only be used to make some simple marker symbols or line symbols, cannot meet the production of complex symbols, and the existing symbols in ArcGIS don't meet the topographic map symbol standards in China. The second method can be used for the production of some complex or special symbols, which can be produced by using raster images. The disadvantage is that it is not easy to control the size of the symbols, and the clarity of the symbols is easily affected by the resolution of the images. In the third method, the font symbols drawn with font editing software are vector graphics, which

have the advantages of small storage space and clear symbol graphics, and can be called by ArcGIS after installing the font file, but the disadvantage is that it is more difficult to control the size and shape of the symbols, and requires the use of graphics drawing software (AutoCAD). In this study, we mainly use the third one in combination with the first method.

The symbol color is an important form of symbol expression. The national standard topographic map uses multicolor or monochrome, and the multicolor map uses cyan, magenta, yellow and black (CMYK), and the color separation is done according to the specified color value [4]. The color separation cannot be done according to CMYK in AutoCAD, and the drawn map is monochrome (black). The font symbols are processed and exported through the FontCreator, and the color separation can be done in accordance with CMYK when editing characters in ArcMap's Symbol Manager according to the specified color value.

The flowchart of the design and production of the symbol library in this paper is shown in Figure 1:

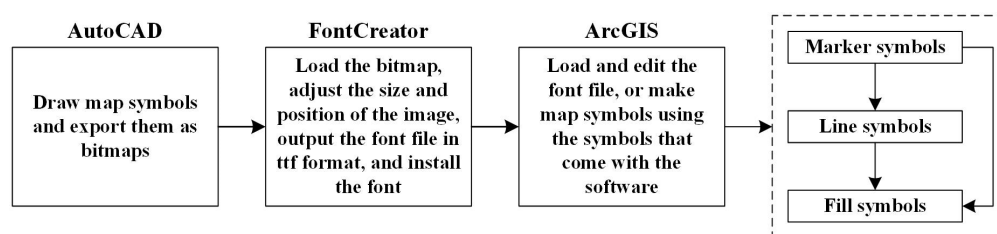


Figure 1. Flowchart of the design and production of the symbol library

3.3. Production of three symbols

3.3.1 Production of marker symbols

Marker symbols are the basis for map symbols. In Style Manager, simple two-dimensional marker symbols can be created in four ways, including arrow marker symbols, character marker symbols, picture marker symbols, and simple marker symbols. Some marker symbols are more complex and cannot be obtained by combining and trimming simple geometric shapes, which can be done by using font symbols or pictures.

The font symbols are vector format, which has the advantage of not distorting with the enlargement and reduction of the symbols themselves, expressing the symbols graphically clear, and the storage space occupied by TrueType fonts is much smaller compared to other formats such as pictures [9], so this paper produces marker symbols by using the font editor FontCreator to generate the font symbols. However, the Chinese national standard topographic map format has very strict rules on the color, size and shape of symbols. It is difficult to precisely control the size and shape of symbols in FontCreator, so various topographic map symbols are drawn precisely with the help of AutoCAD and saved as block files and converted to bitmap format, then imported into FontCreator vectorized to create a library of marker symbol fonts. Finally, the font symbols are added in the symbol editor of ArcGIS.

The process of creating the library of marker symbols is as follows:

(1) In Style Manager of ArcGIS, a new symbol library was created and named with the suffix style.

(2) Using the powerful drawing and editing functions provided by AutoCAD, the marker symbols required in the map symbol library of this paper were drawn according to the style and size regulations of the national standard topographic map pattern, saved as block files in turn, and output as bitmap files respectively, as in Figure 2.

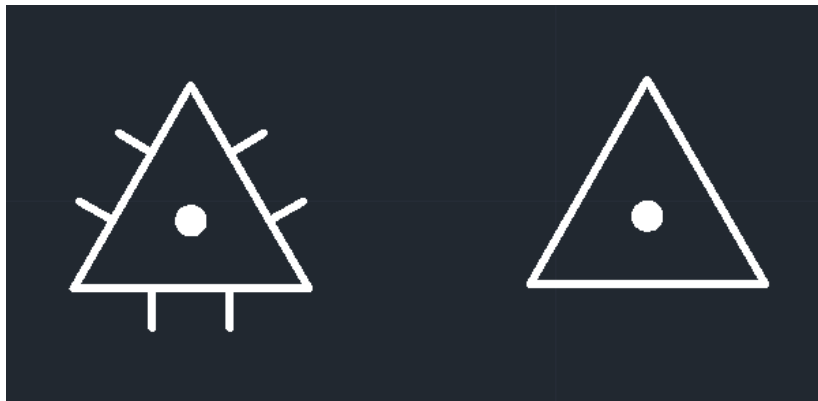


Figure 2. The triangle point symbol drawn in AutoCAD

(3) Create a new font library in Font Creator, empty the existing fonts inside, import the bitmap files of the completed marker symbols into the font template of the font file (.ttf), and adjust the size and position of the symbols so that they are within the range set by the coordinate system of the font template. Figure 3 shows the completed font library of partial marker symbols.

space	A	B	C	D	E	F	G	H	I	J	K
L	M	N	O	P	Q	R	S	T	U	V	W
X	Y	Z	bracketleft	backslash	bracketright	asciicircum	underscore	grave	a	b	c
d	e	f	g	h	i	j	k	l	m	n	o

Figure 3. Font library for marker symbols

(4) The created font is exported as a TrueType font (.ttf) and installed into the system.

(5) The marker symbol library of the topographic map symbol library already created in Style Manager is selected. In the symbol property editor, select character marker symbols for type property, and select the font library that has been created and installed, and import the marker symbols in the font library respectively, use the preview window to zoom in to determine their positioning markers, adjust the size, angle, color and offset parameters as in Figure 4, and modify the symbol name to complete the creation of the marker symbol sub-library (Figure 5).

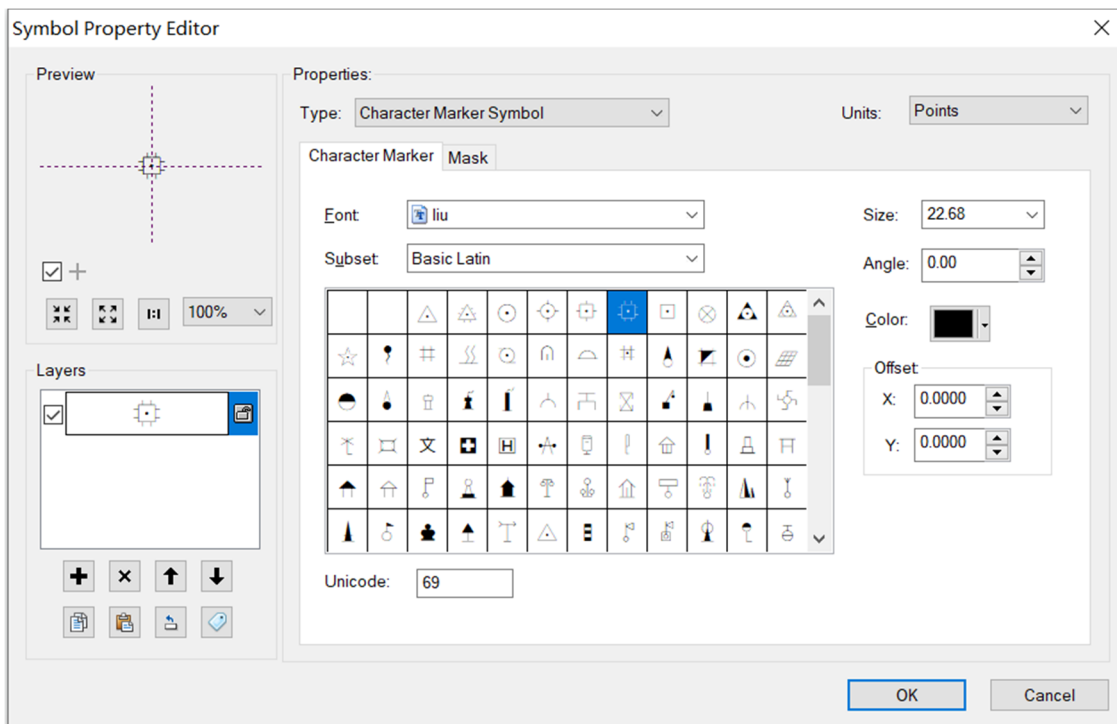


Figure 4. Importing font symbols

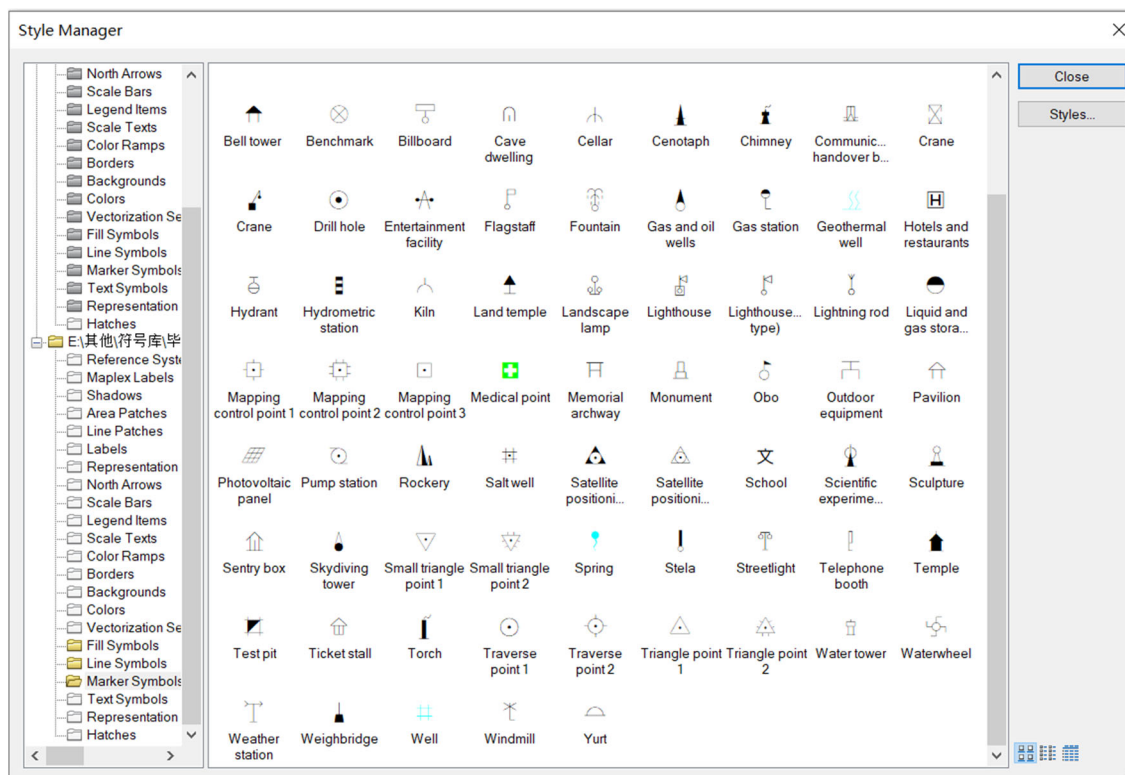


Figure 5. Style library for marker symbols

3.3.2 Production of line symbols

There are some simple line symbols such as fences and river banks, and some more complex ones such as steep banks and power lines. For two-dimensional line symbols, Style Manager provides five different ways to create line expressions, including marker line symbols, mixed

line symbols, simple line symbols, picture line symbols, and mapping line symbols, which can be used separately or in combination to create various line types in topographic map patterns.

There are three cases for line symbols:

(1) Single line symbols, such as solid line, dashed line, dotted line, etc. Simple line symbols can be used to create some solid lines, and graphical line symbols can be used to create some dashed lines, dotted lines, by adjusting the color, width, etc. to complete the production.

(2) The line symbols that can be further decomposed into a single feature can be composed of several line symbols with a single feature [10-11]. At this point, the order of stacking, the offset of the layout on the baseline, the proportional relationship of the symbol unit, etc., can be produced by using multiple line symbol layers stacked. Figure 6 shows the production line diagram of the dike. Line symbols can be made by four mixed line symbols and two cartographic line symbols, by adjusting the line width, offset, line thickness and template.

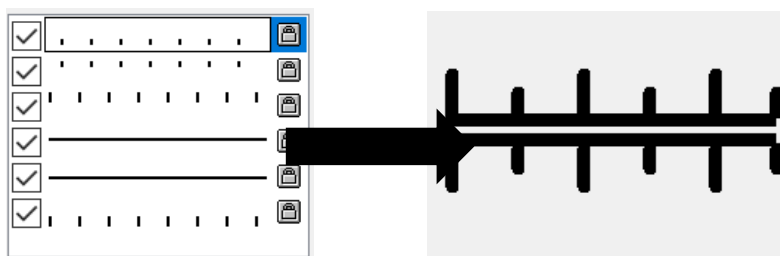


Figure 6. The production line diagram of the dike

(3) A line symbol, analyzed vertically as a combination of basic lines and horizontally as a periodic cycle of marker symbols along the forward direction of the line [12]. Line symbols can be created by using various basic line types and marker symbols or a combination of both to create a cyclic unit. These line symbols are created in two steps: first, a complex or cyclic unit is created as a marker symbol, and then the markers are arranged and extended to form a line symbol, or crossed, combined, or extended with other line symbols to form the desired line symbol. The fence, hedge, underdrain, etc. are shown in Figure 7. Figure 8 shows the library of fill symbols created in this study.

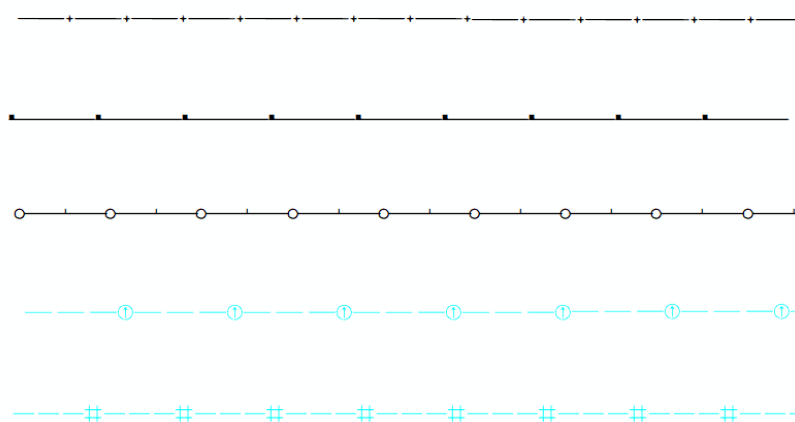


Figure 7. Cyclic line symbols

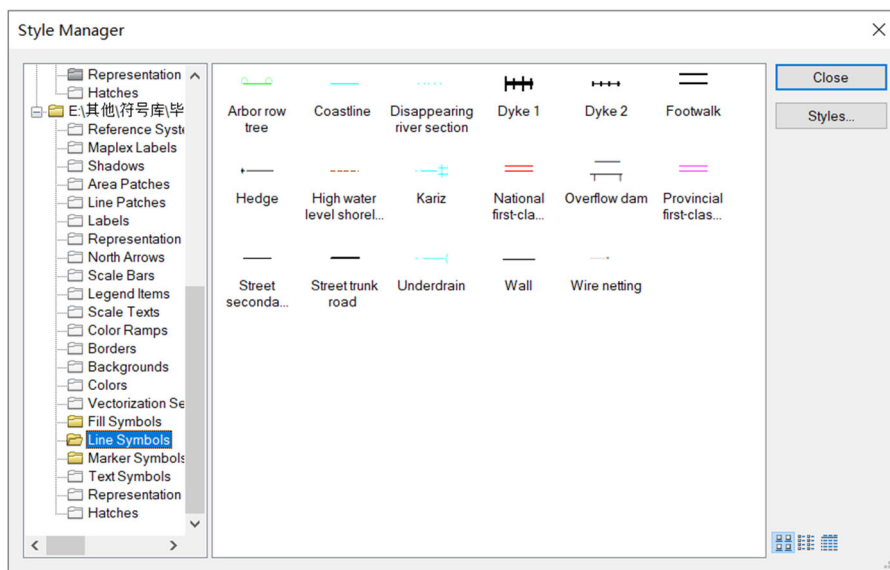


Figure 8. Style library of line symbols

3.3.3 Production of fill symbols

Fill symbols are closely related to marker and line symbols, and their creation requires the use of some marker and line symbols. There are five ways to draw fill symbols in ArcGIS, including marker fill symbols, simple fill symbols, gradient fill symbols, picture fill symbols, and line fill symbols.

There are three cases in the production of fill symbols:

(1) Fill with line symbols

The filling of different fill symbols, such as houses, mud flats and other fill symbols, is done by forming parallel line clusters with a certain angle, certain interval, certain offset and certain real and imaginary length within the contour line of the fill symbols to form different pattern patterns. Simple lines or other line symbols are used to complete the filling of the fill symbols by adjusting the color, angle, offset, interval, etc.

(2) Fill with marker symbols

The complex marker symbols used for filling were drawn in AutoCAD and loaded into the marker symbols of the Style Manager for use in filling the fill symbols. Since the filled marker symbols cannot be rotated and offset between rows in the property editing dialog box of the marker fill symbols, the stacking of multi-layer fill symbols was adopted, which required setting the spacing and offset in different layers and adjusting the rotation position of the symbols when drawing them. By adjusting the spacing and offset of the marker fill symbols in different layers, a “pin” type layout can be formed, as in Figure 9. In addition, it can also form a “well” type and a hash type layout.

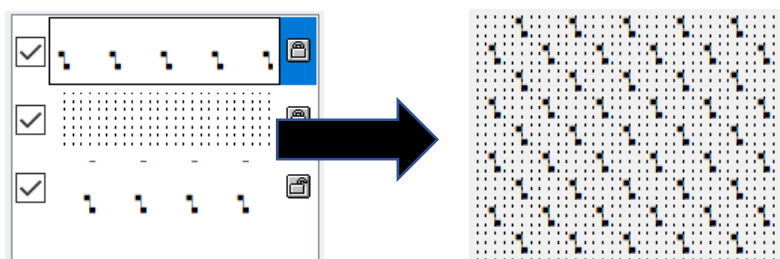


Figure 9. Shellfish farming beach

(3) Fill with color

Select the desired color from the color template to fill. Figure 10 shows the library of fill symbols created in this study.

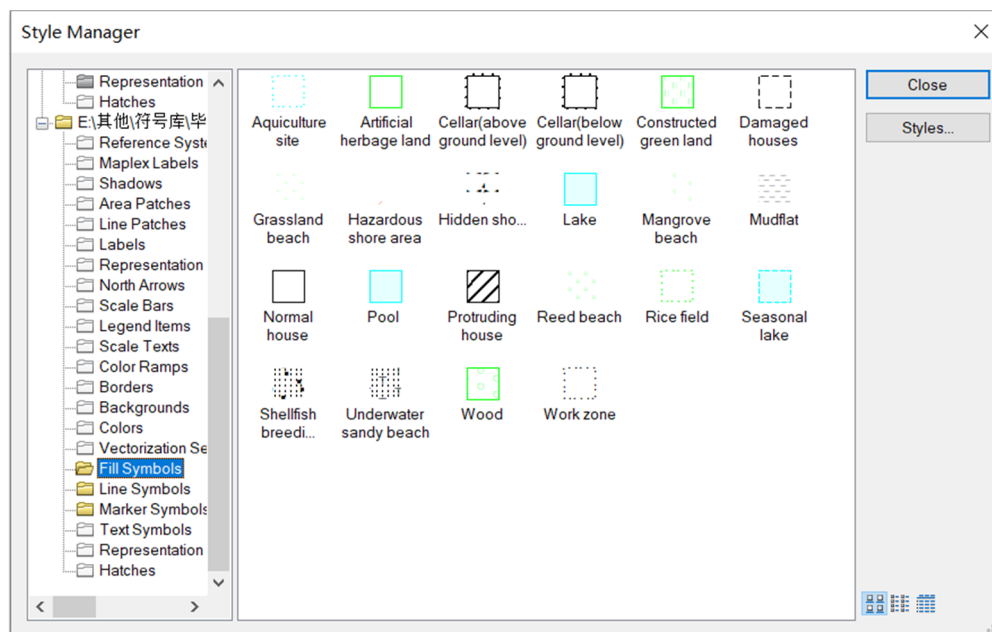


Figure 10. Style Library of Fill Symbols

3.4. Encoding of symbols

In the symbol library, for the coding of each map symbol, this paper adopted the classification and code of Chinese basic geographic information elements, so that they can adapt to each other with the map’s graphical style. Some of the symbol codes are listed in Table 1:

Table 1. Symbol and code

Code	Element name	Geometric type
110102	Triangle point	Point
380203	Fence	Line
250408	Shellfish farming beach	Plane

4. CONCLUSIONS

Based on the functional characteristics of ArcGIS software, the map symbols were drawn and a map symbol library was established with reference to China’s large-scale topographic map format standards, combined with the drafting software AutoCAD and the font editing software FontCreator. This paper mainly discusses the idea of creating a library of map symbols based on ArcGIS and the methods of creating different kinds of map symbols. The map symbols produced in this paper have a good effect, with the advantages of high precision, small storage space, clear graphics, etc., which meet the national standard topographic map format standards and meet the actual mapping requirements, facilitate the use of cartographers, promote the standardization of map symbols, and solve the problems of map symbol differences in GIS software. However, there are shortcomings in this study: some complex symbols such as power lines and slopes have not yet been added to the symbol library, and the above symbols will be added to the library through programming and other means.

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