CARTOGRAPHIC COMMUNICATION FOR A SEARCH AND RESCUE MAP

A Thesis submitted to the faculty of
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In partial fulfillment of
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Master of Science

In

Geographic Information Science

by

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San Francisco, California

December 2018

CERTIFICATION OF APPROVAL

I certify that I have read CARTOGRAPHIC COMMUNICATION FOR A SEARCH AND RESCUE MAP by Mitchell Wilks, and that in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirement for the degree Master of Science in Geographic Information Science at San Francisco State University.

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2018

Cartography is a critical element of search and rescue (SAR), with which map makers and map viewers visualize and communicate. This study, in four steps, evaluated the existing 2011 Marin Municipal Water District (MMWD) SAR Map, produced the 2018 MMWD SAR Draft Map, assessed the usability of the Draft Map, and produced the 2018 MMWD SAR Updated Map. In the evaluate-produce-assess-produce steps, the needs and biases of respondents were articulated in the evaluate-assess steps and informed each production step. The result was a map optimized for use in SAR operations on MMWD by the respondents.

I certify that the Abstract is a correct representation of the content of this thesis.

_____ _____

Chair, Thesis Committee Date

PREFACE AND/OR ACKNOWLEDGEMENTS

This is for people who love Mt. Tam enough to get lost on it and to those willing to painstakingly look for them. I would like to acknowledge Christine McGuinness, Jerry Davis, Nancy Wilkinson, Leo Blesius, John Isom, and XiaoHang Liu. You are all smart, amazing people. Thank you for taking the time to work with me.

Most of all to my family and most, most of all my daughter.

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1.0 Introduction

1.1. Summary

This thesis describes the 17-month process of updating a map for Marin Municipal Water District (MMWD) designed specifically for users who participate in Search and Rescue (SAR) operations on MMWD.

Two areas are explored in the literature review. The first provides a background review of SAR in the context of MMWD, the other explores usability of cartography for SAR on MMWD. The review of literature about SAR on MMWD describes elements of SAR and the organizational structure used by Marin County Sheriff's Office SAR (MSAR). The subsequent section delves into cartographic visualization and cartographic communication as they relate to SAR on MMWD.

Producing the Updated Map included two periods of assessment which alternated with two periods of production. The evaluation-assessment steps informed revisions to the cartographic design. A sample of respondents from the audience of map users participated in the evaluation-assessment steps. During the evaluation they were given ample opportunity to record their views, needs and biases in critique of the former MMWD SAR map (2011) and again during the assessment, providing input to the production of the Draft Map.

Steps in the update process included 1) conducting the Design Criteria Interviews which evaluated the 2011 map, 2) production of the Draft Map, 3) conducting the Draft Map Assessment, which informed 4) the production of the Updated Map. See Figure 1.

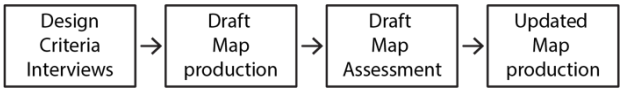


Figure 1: Basic project structure

1.2. Purpose

This objective of this project was to update the MMWD Mt. Tamalpais Watershed 2011 Search and Rescue Map with additional data, locating and naming routes, points of interest,

and historical sites on MMWD. The Updated Map, MMWD Mt. Tamalpais Watershed Search and Rescue Map 2018, was delivered in two forms. One is a printed map sized Architectural D (24 x 36 inches, 609.6 x 914.4 mm); the other is a geolocated digital file to be used by MSAR in their GIS.

1.3. Geographic Scope

The MMWD Mt. Tamalpais watershed land is just less than 19,000 acres (just less than 7,700 hectares) and include drainages of five reservoirs. Watershed lands are bounded by the SE flanks of Mt. Tamalpais in the S; N to Peters Dam on Kent Lake; the margins of the lake drainages to the E of the lakes; and to the W at Bolinas Ridge. See Figure 2.

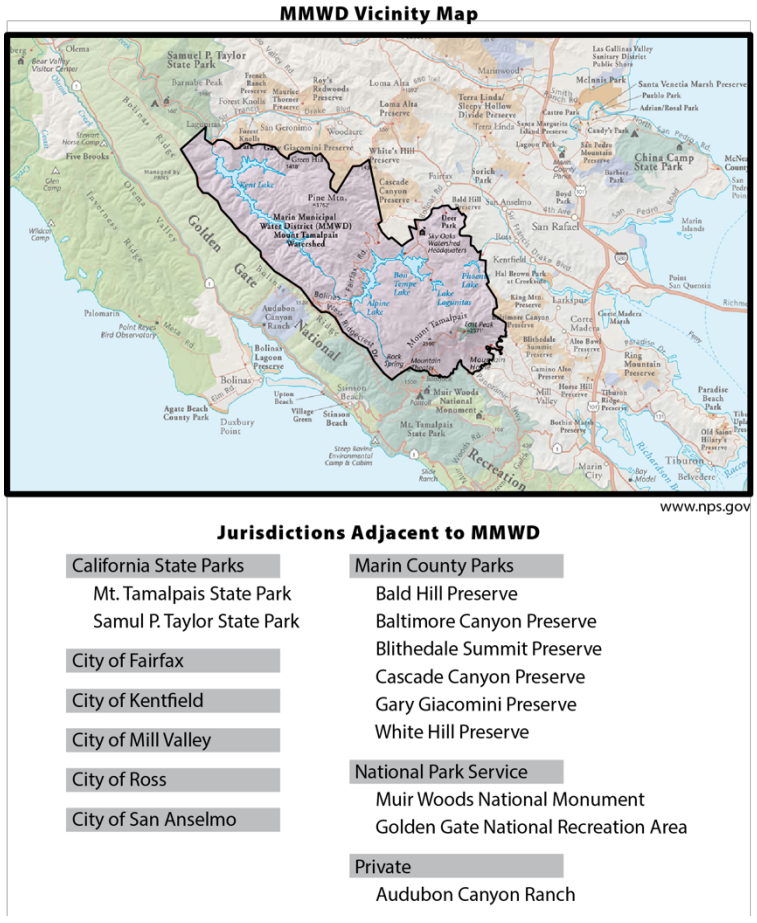


Figure 2: MMWD vicinity and adjacent jurisdictions

1.4. Problem Statement

The MMWD Mt. Tamalpais Watershed 2011 SAR Map was in need of an update. Additional data had been gathered since production of the 2011 map.

Maps now used for SAR on MMWD need to exist in the digital realm. MSAR currently uses a GIS to manage searches. The previous 2011 SAR map is a paper map.

Respondent's needs and biases concerning using SAR map use on MMWD were expressed during assessment sessions. These needs and biases are incorporated into the cartographic design program.

1.5. Project Stakeholders

Five key stakeholders anchored this project. Beginning at the first meeting in August 2017, and in numerous conversations since then, they have each offered critique and exercised the power of suggestion regarding this map update.

Don Wick, Head Ranger, MMWD

Don took time from his busy schedule, kept abreast of this project and facilitated access to Rangers, allowing them to contribute. The Rangers will be one of the primary users of the Updated Map. Their input to this project was important. Wick also provided a few parking passes.

Rich Shelton, MSAR and Rich Riechel, MSAR

Shelton and Riechel are Search Managers and with others they have pioneered the use of GIS for SAR in Marin County. MSAR provided access to their portal at SARTopo.com, one of the primary places where the map produced in this project will be used.

Nick Salcedo, retired MMWD GIS Analyst

Nick was the primary contact within MMWD at the outset of the project. He provided access to spatial data he had developed for the District. He retired in December 2017 but remained involved, providing feedback and other advice.

Jim Irving, retired Chief of the Southern Marin Fire Protection District

Jim has kept an ongoing, active interest in the mapping of MMWD. He has spent significant time in the field walking trails with GPS equipment, locating features. He has also designed several maps that are in use by MSAR with his data. He is currently a large fire automated response consultant.

Matt Cerkel, Ranger, MMWD

Although Matt was not a stakeholder at the outset, it should be noted that he contributed significantly with work that only he could have done. He provided absolute detail with names of routes, points of interest, and historical sites. The depth and breadth of knowledge of MMWD lands that Matt holds is remarkable and was a tremendous asset to this map, making it a particularly relevant update.

1.6. Confidentiality

This map contains sensitive information not intended for public consumption. There are routes and locations on MMWD that are important for SAR and associated professionals to be able to access in order for them to perform their jobs. However, documentation of such routes and locations is not for use by the general public. Routes and locations considered sensitive will not be included in this report.

An example of such sensitive information is “non-system trails,” informal, illegally constructed, or otherwise not part of trail system maintained by MMWD. These trails are frequently the location of lost people and other related problems. Non-system trails also contribute to unmitigated erosion, which is at odds with the primary mission of MMWD, which includes managing natural resources in a sustainable manner providing customers with reliable, high-quality water at reasonable price (MMWD 2005).

The reality is that non-system trails exist, they attract prohibited use, and they can be locations for problems that require SAR intervention. It is a public safety issue that these sensitive routes and locations are explicitly mapped for SAR professionals only and are not shared with the general public.

2.0 Review of Literature: SAR and Usability of Cartography

2.1 Background: SAR on MMWD

While each case of a lost party on MMWD rises from its own circumstance and is therefore unique, the cases share strategic approaches.

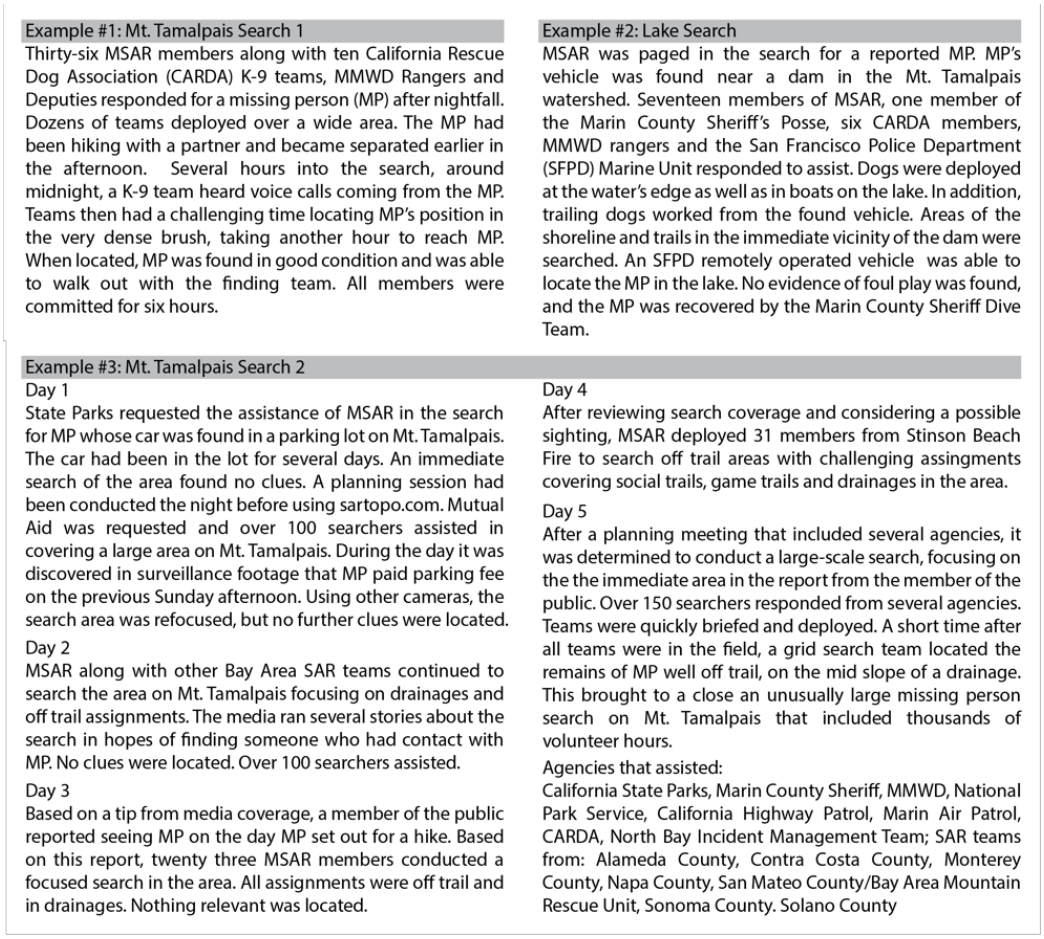
When a lost person is reported on MMWD, that report is usually made to the Marin County Sheriff. MMWD Rangers are notified and they perform a “hasty search” (Marin County Sheriff's Office Search & Rescue, n.d.) within their own chain of command and organizational structure. Reflex tasking is a technique commonly used in the initial part of a search (Koester 2008). The initial hasty search includes not only looking for the missing person (MP) but is intended for SAR personnel to cover large areas quickly, and to collect clues and information that will inform the next operational period of the search (Hill 1998). In many cases, the initial hasty search resolves the case (Koester 2008, Mattson 1976, Hill 1998). The first hours of a search are when most surviving MPs are found (Mattson 1976). MMWD Rangers are professionally familiar with the land and are uniquely qualified to perform this important part of a search.

If the initial hasty search does not resolve the case, MSAR is paged. At this point, the case is referred to as a “lost person incident” (Marin County Sheriff's Office Search & Rescue, n.d., Hill 1998), or just an “incident.” Once MSAR is involved it has at its disposal additional levels of resources, both material and organizational.

MSAR operates within a command structure known as The Incident Command System (ICS), a management system designed specifically for emergency incidents that is used across many domains. The ICS has a modular and scalable organizational structure using common terminology for those trained to use the system. There are also clearly defined procedures to accomplish management tasks such as mobilizing and demobilizing search operations (Hill 1998). An incident can initially be manned by only a few people. If urgency and complexity of an incident grows, management and staffing can increase within the structure of the ICS to hundreds of personnel (Hill 1998).

Once paged, MSAR and enters into a joint command with MMWD and taps into search resources sanctioned by the Sheriff's office that include search managers, information technology infrastructure, ground search units, mounted posse, air patrol, and park rangers, as well as local law enforcement and fire protection. If an incident requires still more resources, the Sheriff can call in Mutual Aid through the California Governor's Office of Emergency Services (OES). The OES sanctions additional assistance from across state and federal agencies (Marin County Sheriff's Office Search & Rescue, n.d.). Such assistance can include K-9, aerial, ground, mounted, or off-highway vehicle search; swiftwater, flood, rope, underground, or underwater rescue; tracking/sign cutting resources; and urban SAR.

Figure 3 presents three mutual aid MSAR incidents on MMWD, demonstrating coordination between agencies. These are real-life examples planned and executed from within the ICS.



Example #1: Mt. Tamalpais Search 1

Thirty-six MSAR members along with ten California Rescue Dog Association (CARDA) K-9 teams, MMWD Rangers and Deputies responded for a missing person (MP) after nightfall. Dozens of teams deployed over a wide area. The MP had been hiking with a partner and became separated earlier in the afternoon. Several hours into the search, around midnight, a K-9 team heard voice calls coming from the MP. Teams then had a challenging time locating MP's position in the very dense brush, taking another hour to reach MP. When located, MP was found in good condition and was able to walk out with the finding team. All members were committed for six hours.

Example #2: Lake Search

MSAR was paged in the search for a reported MP. MP's vehicle was found near a dam in the Mt. Tamalpais watershed. Seventeen members of MSAR, one member of the Marin County Sheriff's Posse, six CARDA members, MMWD rangers and the San Francisco Police Department (SFPD) Marine Unit responded to assist. Dogs were deployed at the water's edge as well as in boats on the lake. In addition, trailing dogs worked from the found vehicle. Areas of the shoreline and trails in the immediate vicinity of the dam were searched. An SFPD remotely operated vehicle was able to locate the MP in the lake. No evidence of foul play was found, and the MP was recovered by the Marin County Sheriff Dive Team.

Example #3: Mt. Tamalpais Search 2

Day 1

State Parks requested the assistance of MSAR in the search for MP whose car was found in a parking lot on Mt. Tamalpais. The car had been in the lot for several days. An immediate search of the area found no clues. A planning session had been conducted the night before using sartopo.com. Mutual Aid was requested and over 100 searchers assisted in covering a large area on Mt. Tamalpais. During the day it was discovered in surveillance footage that MP paid parking fee on the previous Sunday afternoon. Using other cameras, the search area was refocused, but no further clues were located.

Day 2

MSAR along with other Bay Area SAR teams continued to search the area on Mt. Tamalpais focusing on drainages and off trail assignments. The media ran several stories about the search in hopes of finding someone who had contact with MP. No clues were located. Over 100 searchers assisted.

Day 3

Based on a tip from media coverage, a member of the public reported seeing MP on the day MP set out for a hike. Based on this report, twenty three MSAR members conducted a focused search in the area. All assignments were off trail and in drainages. Nothing relevant was located.

Day 4

After reviewing search coverage and considering a possible sighting, MSAR deployed 31 members from Stinson Beach Fire to search off trail areas with challenging assingments covering social trails, game trails and drainages in the area.

Day 5

After a planning meeting that included several agencies, it was determined to conduct a large-scale search, focusing on the the immediate area in the report from the member of the public. Over 150 searchers responded from several agencies. Teams were quickly briefed and deployed. A short time after all teams were in the field, a grid search team located the remains of MP well off trail, on the mid slope of a drainage. This brought to a close an unusually large missing person search on Mt. Tamalpais that included thousands of volunteer hours.

Agencies that assisted:

California State Parks, Marin County Sheriff, MMWD, National Park Service, California Highway Patrol, Marin Air Patrol, CARDA, North Bay Incident Management Team; SAR teams from: Alameda County, Contra Costa County, Monterey County, Napa County, San Mateo County/Bay Area Mountain Rescue Unit, Sonoma County. Solano County

Figure 3: Examples of incidents of missing parties on MMWD. These operations are unique, and they each function within the organization of the ICS. Note the multiple agencies involved. (Marin County Sheriff's Office Search & Rescue, n.d.)

Whether an incident is manned by 20 team members or 200 team members, the structure of the ICS remains the same. Planning is one of five primary functions of an ICS response (Figure 4). MSAR Search Managers function as Incident Commanders and as the Planning Section often at the same time. The work of the Planning Section is dependent on depth, breadth, and quality of spatial data (Zerger & Smith 2003), from data on past incidents to clues pertinent to the incident at hand (Koester 2008).

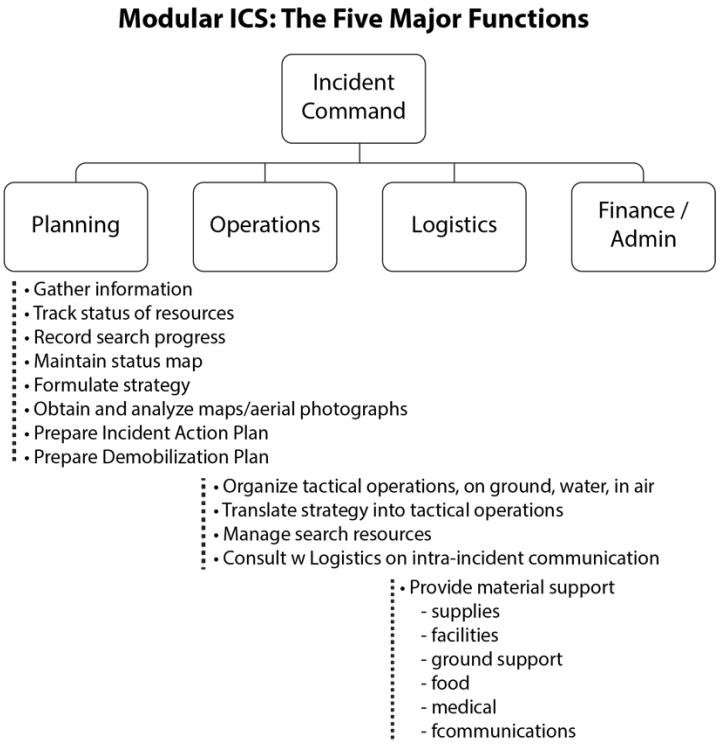


Figure 4: Five functions of the ICS and lists of tasks associated with each function. Drawing adapted from Hill 1998

Gathering information and clues is a critical piece of a search. There are "Five W's" of information gathering: What? Where? When? Who? Why? (Hill 1998, Koester 2008) There are four types of clues or evidence gathered for an incident: physical, documentary, analytical and testimonial (Hill 1998). While spatial data can be gleaned directly from any of these, analytical evidence is derived. Much of the data, information and knowledge that informs decisions made in managing a search are geospatial (Cai, Sharma, MacEachren & Brewer 2006). Figure 5 exhibits lists of clues from two searches on MMWD pointing out clues that contribute to spatial data.

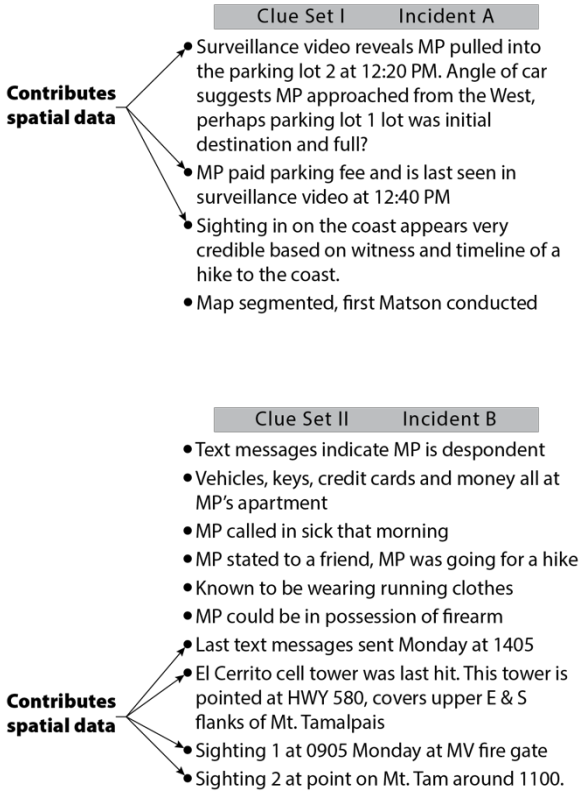


Figure 5: Clues from two searches on MMWD. (Marin County Sheriff's Office, n.d.)

Examples of the use of spatial data are: 1) establishment of the initial planning point (IPP) for the search, which is derived from the last point seen (LPS) and/or the last known position (LKP) of the MP (Koester 2008, Hill 1998), 2) projection of a theoretical search area, a circle centered on the IPP based on estimation of a maximum distance the MP could have traveled in the time elapsed, and 3) assignment of probability of area (POA) the probability that the MP is in a given search segment or location (Koester 2008, Hill 1998). Spatial data, both current and past, is a key element in resolving a lost person incident (Koester 2008).

Lost Person Behavior by Robert J. Koester is a reference that presents statistical analysis of data from past searches. The book contains detailed descriptions of 30 MP subject categories, providing statistics, reflex task lists, and suggestions for further investigative

questions for each subject category. See elements of subject categories in Figure 6. Additionally, see examples of the statistics for three subject categories in Appendix A.

Subject Categories

Purpose: Presentation of lost person behavior by subject category

Using:

- Statistics
- Results by temperate or dry domain
- Source: ISRID

Subject categories determined in order of:

- Mental Status
- Age
- Primary activity

Subject statistics:

- Distance from IPP
- Elevation change from IPP
- Mobility hours
- Dispersion angle
- Find location
- Track offset
- Survivability
- Scenario

Subject types:

- Abduction
- Aircraft
- Angler
- ATV
- Autistic
- Camper
- Caver
- Child (in four age bins)
- Climber
- Dementia
- Despondent
- Gatherer
- Hiker *
- Horseback rider
- Hunter
- Mental illness *
- Mental retardation
- Mountain biker *
- Other
- Runner
- Skier-alpine
- Skier-Nordic
- Snowboarder
- Snowmobiler
- Snowshoer
- Substance abuse
- Urban entrapment
- Vehicle related
- Water related
- Worker

* See Appendix J for subject statistics

Figure 6: Summary of subject categories (Koester 2008).

Understanding lost person behavior is a necessary skill for the search manager to have, however, in the workflow of the incident command post (ICP) products from the Planning Section (e.g. maps and knowledge generated from analysis of maps) are disseminated to other sections (e.g. Operations, Logistics) and they help govern actions on the ground. The usefulness, efficiency, and effectiveness of the cartographic materials in this workflow are elements of usability of those materials (Rubin, & Chisnell 2008).

GIS allows quick overlay of data from different domains (e.g. geographical and behavioral data), and visualization of past search data, of local geography and routes, as well as

documentation of the current incident (Hill 1998). GIS operations used to inform search strategy include Boolean overlays, buffering, and spatial analysis (Heth, Cornell & Dostatni 2006).

Maps generated and viewed on computers or mobile devices can offer immediacy, relevancy and ability to share them (Cai, Sharma, MacEachren & Brewer 2006). However, the paper map prevails in a crisis scenario. There are significant constraints on maps displayed on electronic devices including susceptibility to extremes of heat and cold, and water damage. Technology is dependent on battery life. If there is a blackout, or no ability to recharge devices, both of which occur during crises, paper maps are a logical redundancy (Brooks & Swaminathan 2010, Cai, Sharma, MacEachren & Brewer 2006, Rose 2015, Stachoň et al 2016). Field studies by Zerger and Smith in Queensland, Australia in 2003 concerning a cyclone disaster training scenario found that crisis managers required having access to paper maps in case GIS systems were too slow, or there was a power failure. Additionally, data quality, computing power, and training emerge as constraints on using GIS or electronic displays in real-time crisis situations. A search manager is tasked with making decisions critical to success of the mission, a priority over needing to resolve information technology issues (Cai, Sharma, MacEachren & Brewer 2006, Zerger 2003). Sufficient and nimble computer power, GIS, and output capacity should be complemented in the ICP by ready availability of paper maps. See Figure 7 for an example of what a search manager's work area in the ICP might look like.

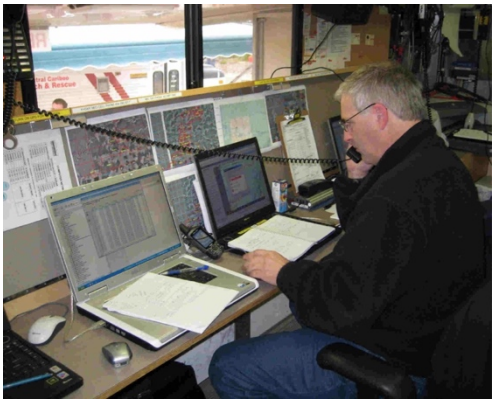


Figure 7: What a search manager's work area in the ICP might look like, computer screens backed by paper maps. Photo: SAR Technology, Inc. (n.d.). Retrieved December 2017, from www.sartechnology.ca/sartechnology/ST_Consultation.htm

2.2 Usability of Cartography for SAR on MMWD

Cartography is defined as the use of points, lines, polygons, colors, lettering, symbols, and other graphic media in graphical techniques (Robinson 1952) to represent data as it is spatially distributed. Maps contain cartography.

MSAR uses cartography to visualize the milieu, any aspect of the cultural and physical world (Robinson & Petchenik 1976, Dent 1999); and to graphically communicate spatial inventory, analysis and synthesis (Petchenik 1979). For example, visualization allows search managers to distill search strategy from clues and other information, and to direct execution of that strategy. Inventory and synthesis are communicated when operations are documented during an incident (Hill 1998).

When a search manager sets out to resolve an MP incident s/he has a range of tools that can be used (Koester 2008). GIS is one of these tools, used to do spatial analysis and to create maps. Maps are used by individuals to visualize the search area. They are also used to communicate between parties working on the search. This project assessed usability of a map for enabling cartographic visualization and communication in the context of SAR.

When respondents participated in the Draft Map Assessment in this project, each was given a set of assumptions that contained the objectives of the assessment, a definition of usability, and explanations of four elements of usability.

Usability is broadly defined as “When a product or service is truly usable, the user can do what s/he wants to do the way s/he expects to be able to do it, without hindrance, hesitation, or questions” (Rubin, & Chisnell 2008). Further, usability in this project is the degree to which the following elements of cartography are enabled in the context of SAR on the MMWD Mt. Tamalpais Watershed Search and Rescue Map:

1) Cartographic visualization; when spatial data on a map is being created or viewed, the cartographer or the person looking at the data uses cognitive tools to interpret what s/he is looking at, be it the real world or the map itself (Board 1972, MacEachren, Buttenfield, Campbell, DiBiase, & Monmonier 1992, MacEachren 1994b).

2) Cartographic symbolization; critical pieces of the language of a map, these are visualizations in themselves (Stachoň, et al 2016).

3) Cartographic communication; when cartographic visualization decreases, resulting in arrival at a particular configuration of the map that is then committed to display, either printed or electronic (Board 1972, Koláčný 1968, MacEachren, Buttenfield, Campbell, DiBiase, & Monmonier 1992, MacEachren 1994b).

Cartographic Visualization

Cartographic visualization is a mental process that employs cognitive tools enabling visual analysis (Wood & Brodlie 1994, Hallisey 2005). In 2001, Crampton referred to it as “geographic visualization”, saying that it is the ability to explore and analyze spatial data and recognize patterns in the data. This visual exploration and analysis enable the generation of hypotheses, development of solutions to problems, and construction of knowledge (Kraak 2003, Hallisey 2005), leading to the discovery of what was not previously known (Dorling & Fairbairn 2013, Hallisey 2005). Using paper maps and maps on electronic displays (MacEachren, Buttenfield, Campbell, DiBiase, & Monmonier 1992, Hallisey 2005), cartographic visualization reaches for what was previously unknown, employing high levels of interaction between the map and the person viewing the map

(MacEachren 1994b, Hallisey 2005). The interaction is characterized by iterative comparison of observations with knowledge (MacEachren 1994b, Hallisey 2005).

During a SAR incident, the scene in the incident command post (ICP) can be fast-moving and stressful. SAR incidents are characterized by their urgency (Hill 1998). Under these conditions, search managers are selectively perceiving the milieu, doing visualization, and making maps with search instructions for distribution to field personnel. Managers consult with each other, usually working in groups of up to four people (Heth & Cornell 2006), sharing information, knowledge, and judgement (Cai, Sharma, MacEachren & Brewer 2006). These interactions are enabled by technology (computers, GIS, electronic displays, and mobile devices). The emergent collective comprehension is greater than what the individual mind may execute (Weick & Roberts 1993, Bigley & Roberts 2001). The dynamic is "a continual give-and-take between vision and visual cognition" in the context of knowledge (MacEachren 1994b, Hallisey 2005). In addition to the advantages of this collective comprehension, the processing power and rapid display brought to bear by technology increase immediacy, relevancy, and sharing (Cai, Sharma, MacEachren & Brewer 2006) of inventory, analysis, and synthesis of data (Petchenik 1979). MSAR Search Managers produce maps in the ICP that convey instructions from this synthesis.

An example of iterative comparison of observations with knowledge in the context of a team (that can be larger than the groups of four people observed by Heth in 2006) is a method used to determine POA called a "Mattson." A Mattson is a facilitated group exercise that is undertaken as the hasty search and reflex tasking run their course and do not resolve the incident. It involves segmentation of the search area map, gathering participants familiar with the incident, ensuring that participants have the same level of background information, polling the participants regarding POA in the segments, aggregating the results of the poll, and assigning POA scores across the map (Koester 2008). The process incorporates clues, information gathered, GIS analysis, iterative comparison of observations with knowledge from the participants, and guide creation of imminent search instructions.

Such instructions issued are to field searchers (as paper maps or electronically for use on mobile devices) who take them into the field, do visualization and take action in the real world by performing searches based on their visualization (Board 1972, Koláčný 1968). The visualization and searching field personnel conduct is heuristic, that is, iterative, guided by knowledge gained along the way (Heth & Cornell 2006).

The maps produced by MSAR are made using a GIS product known as SARTopo, a web 2.0 application available at www.sartopo.com. SARTopo allows display of overlaid maps with transparency and GIS analysis such as, expected travel distance, elevation change, and terrain features (roads, trails, streams, lake shores, coastlines, elevation, slope angle, land cover, ridges and drainages) (Jacobs 2015, Mountaineer Area Rescue Group 2016). The map produced in this project has been tested in SARTopo.

Cartographic Symbols

Cartographic symbols are themselves visualizations (Board 1972, Stachoň et al 2016). They represent elements of the milieu, whether it is a physical location like a picnic area or a derived generalization such as trails over 10% grade. In the early 1970s, as models of cartographic communication began to gain prominence, two German cartographers, Freitag (1971) and Hake (1973), developed models that included notions of cartography as a language. They did this by identifying syntactics, semantics, and pragmatics as elements of semiotics, the study of signs, symbols, and their use or interpretation. These terms are normally associated with linguistics, yet they overlap with semiotics (Board 1972).

In his wide-ranging 1972 article titled Cartographic Communication, Christopher Board defines the terms “syntactics,” “semantics,” and “pragmatics” in the context of semiotics. Syntactics concerns the relationship between cartographic symbols and rules concerning how they are used together on maps. Semantics concerns the relationship between cartographic symbols and what they represent in the real world; their meaning on a map (Board 1972). Pragmatics concerns the interplay between symbols and those interpret them (Casti 2000). See a summary of semiotics in Figure 8.

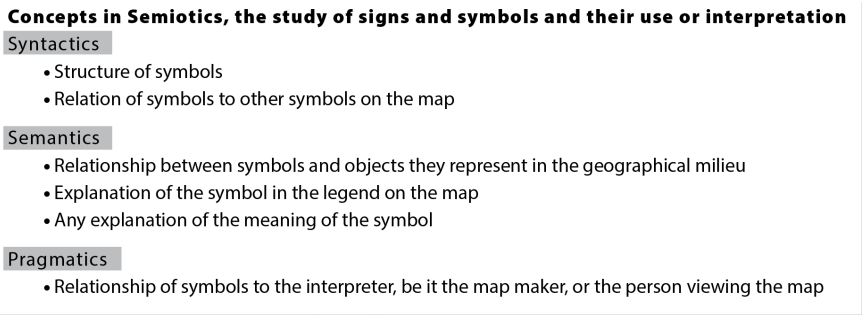


Figure 8: Concepts in semiotics (Board 1972)

While semiotics considers how symbols are part of a system of visualization or communication, there are other principles that are important to the design of symbols. In his 2016 paper "Cartographic principles for standardized cartographic visualization for the crisis management community," Zdeněk Stachoň explored methods to design a unified symbol set for crisis management and related fields in the Czech Republic. As is shown in the design breakdown for the symbol set in that project (Figure 9), shapes represent "what" something on the map is, either an object or a generalization; and colors represent an administrative unit associated with the object or generalization.

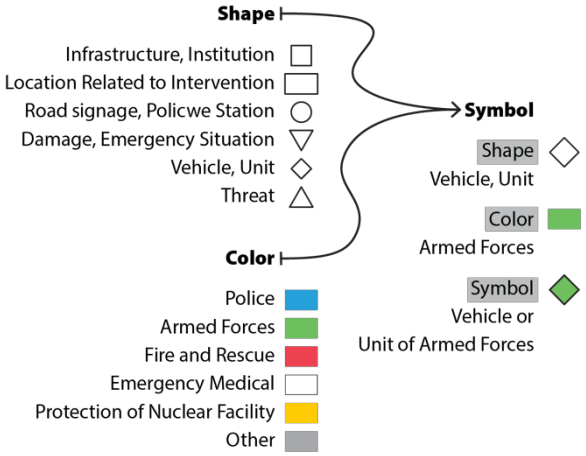


Figure 9: Design of symbols based on shape and color. Adapted from Stachoň et al (2016) by M. Wilks.

In creating his symbol set, Stachoň articulated four principles that guide how symbols are designed. The principles are significance, composition, intensity, and dynamics. The principle of significance dictates that objects with a higher magnitude of significance to the message of the map appear more distinctly than objects of lower magnitude of significance.

For example, primary circulation nodes on a map are represented as squares that are larger than the more numerous, smaller dots that represent secondary points of interest. The principle of composition states that a symbol should appear differently than the object or generalization it represents in the milieu. The principle of intensity addresses the distinctness of a symbol as it relates to the magnitude of the phenomena it represents. For example, when symbolizing the number of people that live in two areas, a more distinct symbol would be used to represent the area with higher population than the symbol used to represent the area with lower population. The principle of dynamics governs how symbols that represent phenomena that are not static shall be represented. For example, a symbol for a moving car has to move on an electronic map per its changing GPS coordinates. See a summary of these principles in Figure 10.

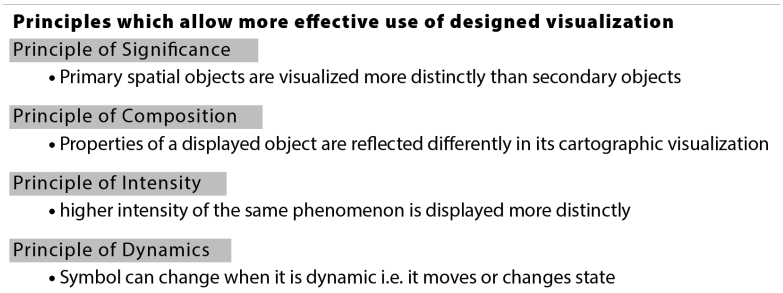
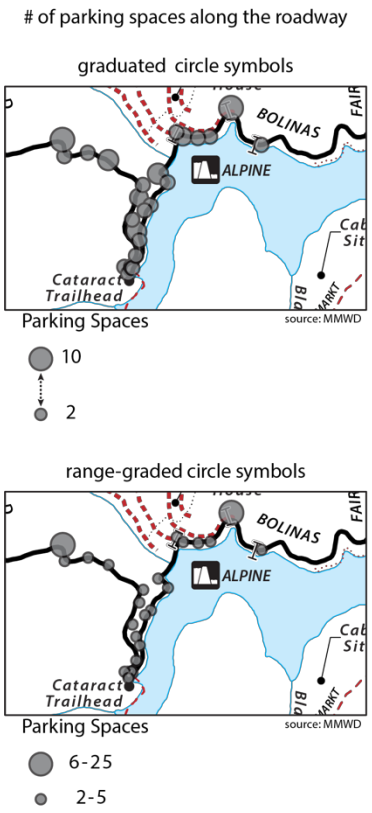


Figure 10: Summary of principles of design of cartographic symbols (Stachoň, et al 2016).

Circle symbols, which are common on thematic maps (Dent, Torguson & Hodler 1999, Brewer & Campbell 1998) engage the principles of significance and intensity (Stachoň 2016). They have been the subject of much research. Circles are geometrically compact forms (Dent, Torguson & Hodler 1999), which have uniform and smooth edges, unlike squares or triangles which have corners. Because of this quality, circles can also overlap (in reasonable configurations), and maintain their ability to represent quantities. (Dent, Torguson & Hodler 1999). Circle symbols can be graduated, that is sized such that the area of the circle symbol is proportional to the magnitude of the quantity it represents (Brewer & Campbell 1998, Dent, Torguson & Hodler 1999, Meihoefer 1973); they can also be range-graded, that is when data being represented is divided into groups and each group is represented by different circle sizes that are clearly distinguishable. Use of range-graded

circles leads to fewer mistakes by map readers in understanding what the circles represent (Dent, Torguson & Hodler 1999). Whereas values of graduated circles cannot be perceived by most map readers relying on visual inspection and comparison of relative sizes on a map. Similarly, continuously graduated circle symbols with small differences in size cannot be differentiated. Comprehension of such values is dependent on an effective legend (Meihoefer 1973). Figure 11 allows comparison of graduated circle symbols with range graded circle symbols both in the context of a map and without the context of a map.



# of parking spaces	graduated circle symbols	range-graded circle symbols	# of parking spaces
10			6-25
2			2-5
2			2-5
2			2-5
4			2-5
2			2-5
10			6-25
2			2-5
2			2-5
5			2-5
5			2-5
2			2-5
2			2-5
4			2-5
2			2-5
2			2-5
2			2-5
5			2-5
2			2-5
2			2-5
2			2-5
2			2-5
2			2-5
2			2-5

Figure 11: Graduated circle symbols versus range-graded circle symbols as they appear in the context of a map (left) and without the context of a map (right). The Meihoefer (1973) article entitled "The Visual Perception of the Circle in Thematic Maps" made similar comparisons of circles in the context of a map and without the context of a map. Note the difference of ease of visual distinction between the graduated circles and the range-graded circles. Drawn by M. Wilks

Stachoň's principle of intensity is readily incorporated into use of circle symbols. The principle of intensity dictates that circles representing higher magnitude of an element on the map appear larger than circles representing a lower magnitude. A problem borne out of

consideration of circles and the principle of intensity is how much larger is large enough? Hans Meihoefer's 1969 article conducted empirical research into this question and the Meihoefer Circle Sizes (Figure 12) are the result. As range-graded circle symbols are visualized together in a cartographic scheme, these graphic or visual ratios between circle size allows differentiation between the classes being represented.

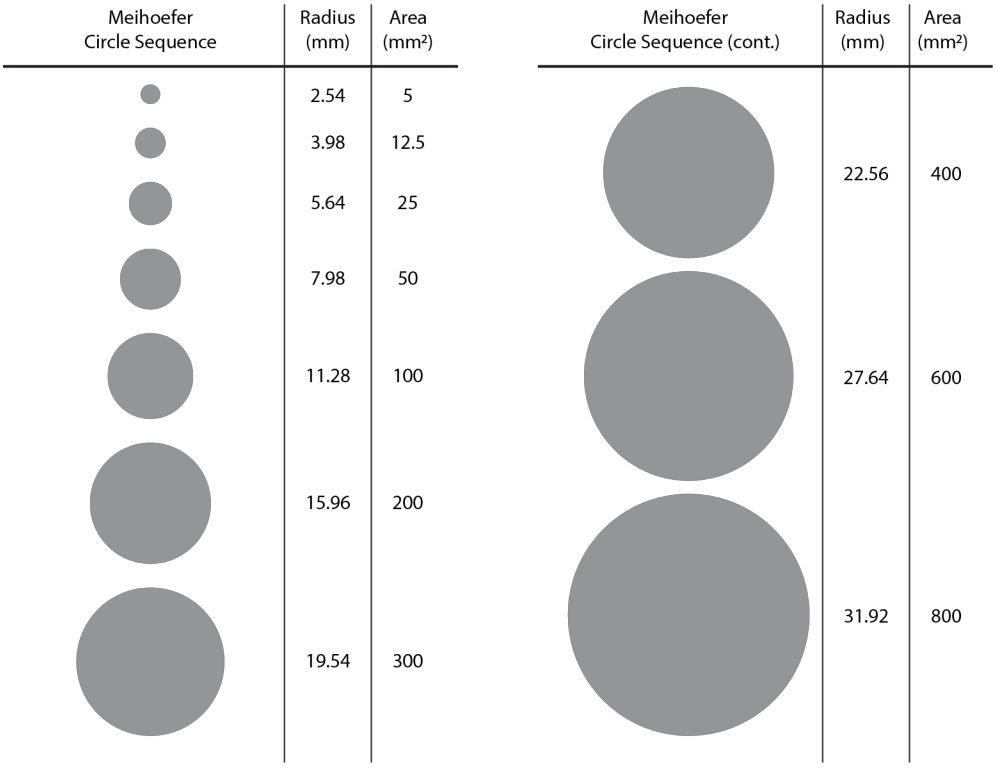


Figure 12: Meihoefer circle sizes (Dent, Torguson & Hodler 1999). Redrawn.

As cartographic visualization brings together the most relevant elements to convey the intended message, the visualization dynamic slows and the cartographic objective shifts from exploration, analysis, and synthesis (MacEachren, Buttenfield, Campbell, DiBiase, & Monmonier 1992), to presentation of the relevant material, usually as a map. Even after this shift to the presentation phase (known as cartographic communication) visualization of symbols continues. The symbols and the visualization of the symbols are part of the language of cartography.

Cartographic Communication

When the dynamic of visualization leads to output of a map it becomes a static element within a communication process. Models of cartographic communication tend to be linear and to involve a map maker (production) and a map viewer (consumption), with the map at the center. Cartographic communication is a singular system in which cartographic information originates, is communicated and has an effect (Koláčný 1968). There are many models of cartographic communication.

In their 1975 article “The Map as a Communication System,” Arthur Robinson and Barbara Petchenik cite Singh (1966) as the author of a simple model of communication (Figure 13). In this model, the source is analogous to the voice of a person speaking, the channel to the air carrying the sound waves of the speaker’s voice, and the recipient to the person hearing the sound waves (Robinson & Petchenik 1975).

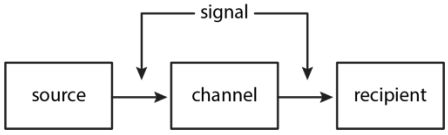


Figure 13: Fundamentals of a simple communications system. Singh (1966). Redrawn.

Other models demonstrate input, output and flows (Robinson & Petchenik 1975). The diagram in Figure 14 is drawn from research in the 1950's about place-to-place communication, an early name for telecommunications. Early innovations in the development of telecommunications were the telegraph in 1844, voice over a telephone line in 1876, and wireless telegraphy in 1895 (Johnson & Klare 1961). Given that origin, the idea of noise, which is interference with the signal (Robinson & Petchenik 1975), is easy to understand as static on the line.

In his 1967 article "Maps as Models," Christopher Board adapted a model of general communication (Johnson & Klare 1961) to arrive at the model shown in Figure 14. Examination of analysis of the model shown in Figure 14 by both Board and by Robinson and Petchenik, reveals a comparison of the source to the real world (Board 1967), the encoder to symbols on a map, the coded message (on the production side) to the map, the

signal to reflected light emanating from the map, while the decoder and the destination is the eyes and mind of the reader turning the light waves into thoughts (Robinson & Petchenik 1975).

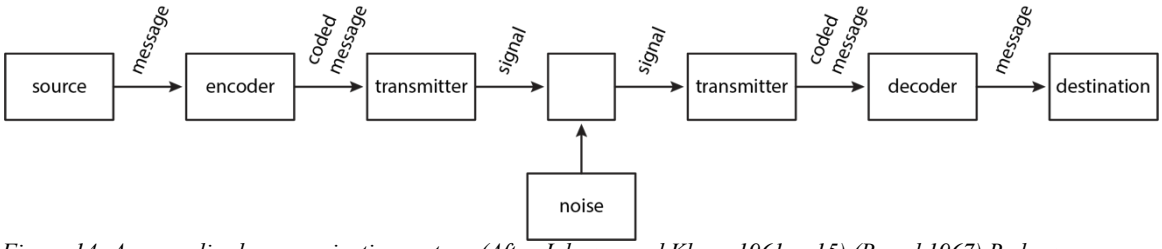


Figure 14: A generalized communication system. (After Johnson and Klare, 1961, p.15) (Board 1967) Redrawn.

In a general communication model, noise is interference with the signal, electronic noise. In a cartographic model noise is graphic. Distracting elements such as prominent patterns on a map, dense or overpowering lettering, or simultaneous contrasts of hue and value are examples of graphic noise (Robinson & Petchenik 1975). The Map-Model cycle features sources of noise coming from the both the map maker and the map user to affect the message (Board 1972).

Following are three examples of models of cartographic communication ranging on a timeline from the 1960s thru the 1970s. The 1968 model by Koláčný is shown in Figure 15. Board's 1967 Map-Model Cycle is shown in Figure 16, and MacEachren's 1979 diagram of cartographic communication is shown in Figure 17.

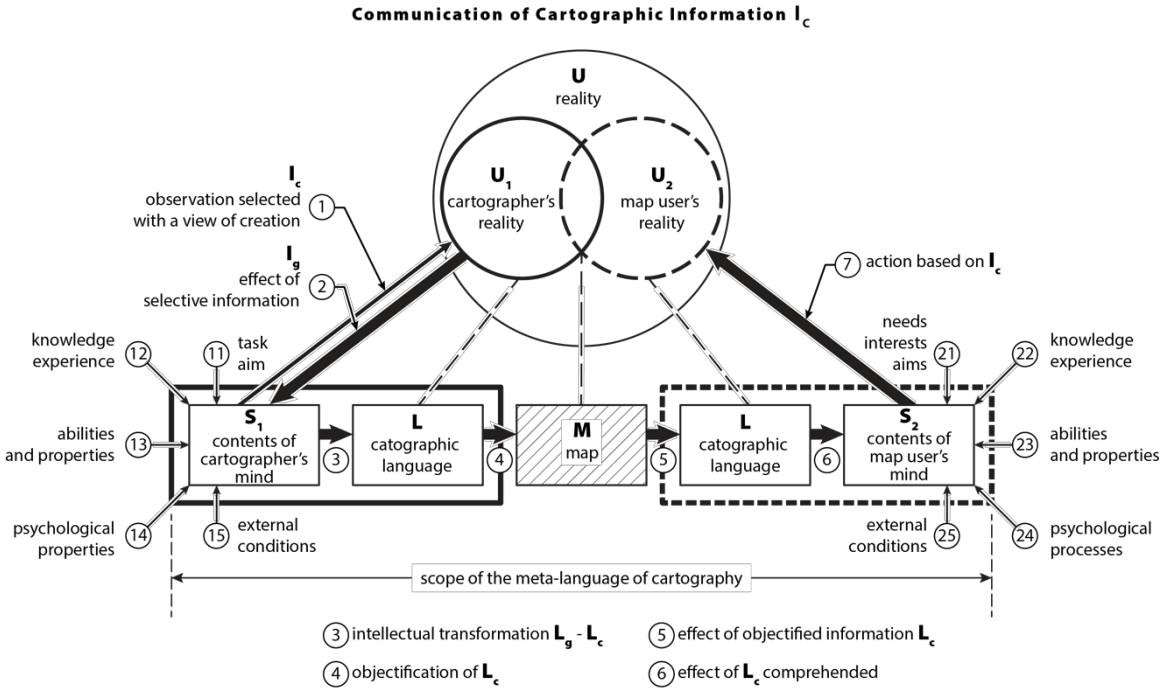


Figure 15: Koláčný's model of cartographic communication (1968). Redrawn.

Koláčný's model uses both a Venn diagram and a linear model in parallel. The Venn diagram portion is significant as it directly joins the map maker and the map user in the process yet separates them in the linear portion of the model (Board 1972).

In Board's 1967 Map-Model Cycle, the map-making components are generally down the left side of the diagram, while analysis components are generally up the right side. At its worst this model was critiqued by Alan De Lucia as an engineering-like model, however Board concurs with Robinson and Petchenik who called it a broad analogy.

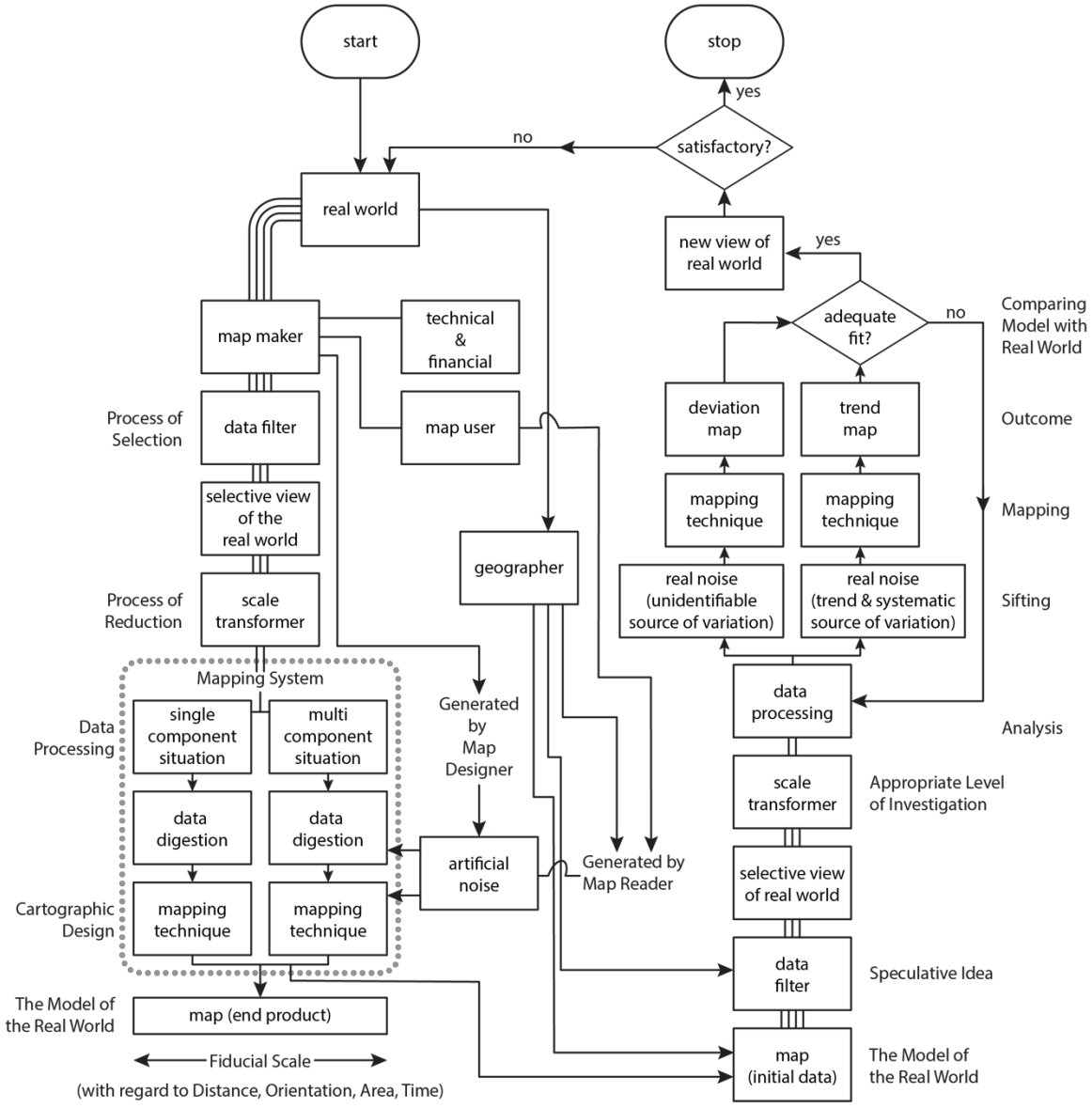


Figure 16: Map-Model Cycle, Board (1972). Redrawn.

While early models by Koláčný and Board are pertinent and thoughtful, the model created by MacEachren in 1979 highlights a model more applicable to SAR operations in the ICS. In the upper part of the diagram where the cartographer's knowledge and the percipient's knowledge are placed in "reality" and "not reality," there is a small region that is tacked on to the recipient's knowledge. That is "knowledge gain," an important element of cartography in the context of SAR on MMWD.

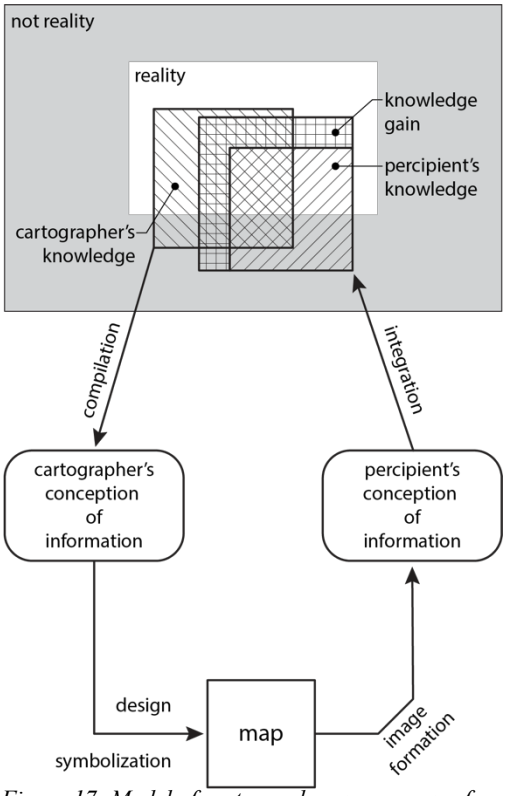


Figure 17: Model of cartography as a process of graphic communication (MacEachren 2004). Redrawn.

When field personnel search the tracks indicated on a map of instructions, the searcher has gone out into the real world, has made observations, and has gained knowledge. That knowledge is then fed back to the search manager who uses it to continue to devise strategy. As this loop continues, knowledge grows and that is one way that searches are resolved. That knowledge gain, so important to SAR, feeds the search planning process.

The ICS is well suited to efficient distribution of cartography across the breadth of its organizational structure. The development, communication, and nesting of operational representations "gives rise to a collective representational infrastructure helping to protect individual members against cognitive overload and facilitating appropriate moment-to-moment interrelating of their behaviors" (Bigley & Roberts 2001) In other words, looking at a unified cartographic technique across an incident (be they interactive visualization graphics in the ICP, or maps distributed to search teams, used by logistics, or public

relations) reduces cognitive overload. People looking at the maps do not have to translate the symbol for a road or a trail each time they look at a map, any map, on an incident. Unified cartography within a search organization makes it easier for those who are using it to function in the dynamic, urgent atmosphere of SAR (Doherty 2010, Stachoň et al 2016). Figure 18 highlights parties who could typically exchange cartography or operational representations during a SAR incident, and what cartographic messages could be in those exchanges.

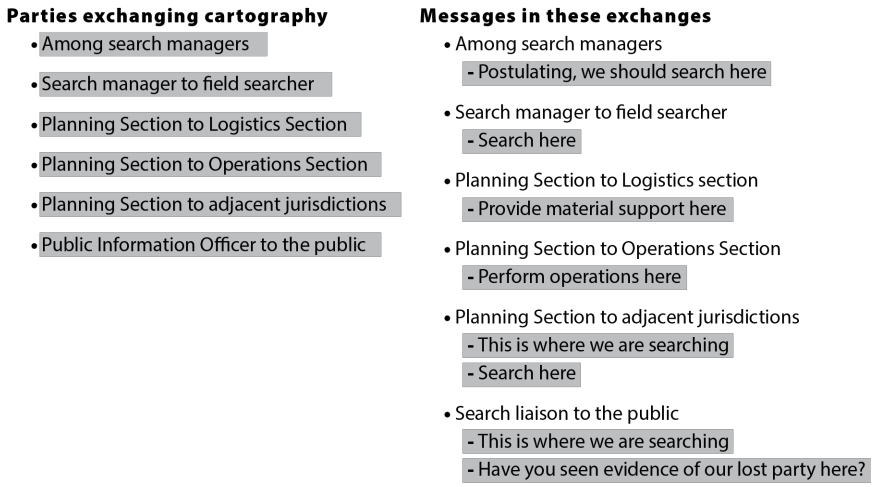


Figure 18: Parties who typically exchange cartography or operational representations during a SAR incident, and what cartographic messages could be in those exchanges.

More broadly, there are different kinds of maps (Board 1972, Guelke 1977, Petchenik 1979) used for different purposes. An early classification, that of geographically concrete maps versus geographically abstract maps, differentiated between displaying concrete aspects of the milieu (e.g. distribution of land and water, elevations) and displaying incidental information in a generalized way (e.g. commercial, statistical, ethnographic), usually conveying the work of scientists (Eckert & Joerg 1908). A later take on this classification is that of general reference maps versus thematic maps. General reference maps derive their meaning from the human experience of "being-in-place" (Petchenik 1979). For example, showing a network of trails and their names. Thematic maps, more cognitively demanding than general reference maps, provide meaning from the experience of "knowing-about-space" (Petchenik 1979) as for example, a map that shows analysis of

the steepness of trails. Both of these classifications portend that certain characteristics on a map put it in one class or another. However, it is not that simple. The difference between map types exists along a continuum that does not always have clean breaks between types (Petchenik 1979). For example, a topographic map is a general reference map in that it shows what is concretely in place (topography), and it is also a thematic map in that it represents steepness, aspect, or drainage, which are generalizations about locations. Classification of maps evolved to look beyond the characteristics of the map itself to incorporate the experience of the person viewing the map, what the map is used for, and what meaning the map holds (Guelke 1977). Classifications of inventory, analysis, and synthesis reflect this view where maps derive meaning from the human experience (Petchenik 1979).

Cartographic Visualization and Communication on a Continuum

Figure 19 is a diagram of three-dimensional space that locates cognitive processes on a continuum between cartographic visualization and cartographic communication (MacEachren 1994).

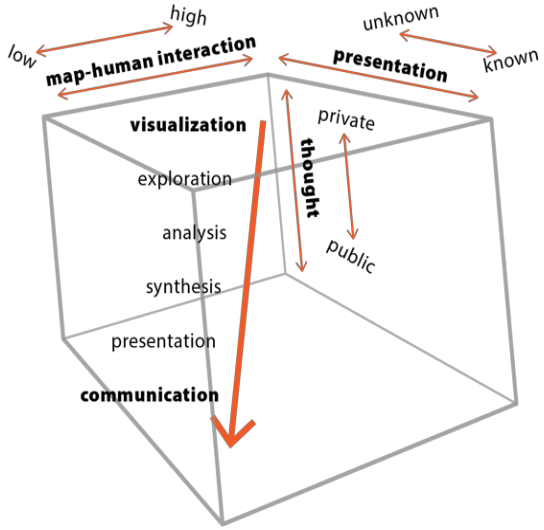


Figure 19: Representation of the three-dimensional "space" of map use visual displays (MacEachren 1994). Redrawn.

Visualization and communication are complementary, yet all map use involves both visualization and communication. MacEachren & Kraak provide working definitions; of

visualization, as the prompting of visual thinking and knowledge construction; and communication, as the transfer of information. Activities along the continuum (exploration, analysis, synthesis, and presentation) occur in the context of three dimensions. The dimensions are thought from private to public, map-user interaction from high to low, and presentation from knowns (i.e. simple information retrieval) to revealing unknowns. Exploration answers questions about the nature of a data set and how the data relates to the problem at hand. Analysis involves the manipulation of known data in search of unknown relationships. Synthesis looks beyond single data sets toward multiple data sets, presenting multiple known analyses in search of unknown patterns or relationships. Presentation includes both transfer of a predetermined message and the prompting of new insight on the part of the person who accesses the presentation. (MacEachren & Kraak 1997)

3.0 Method

In 2013, Kveladze, et al described a case study that assessed a particular graphic as a visualization tool. He found that passage through the problem-solution-evaluation cycle facilitates an evolution of design guidelines and that interviews with domain experts can foster a user-centered approach to identifying cartographic problems (Kveladze, Kraak & van Elzakker 2013). The Design Program in this project is analogous to the design guidelines highlighted by Kveladze, et al; and the stakeholders are analogous to the domain experts highlighted by Kveladze, et al.

The 2018 MMWD Mt. Tamalpais Watershed Search and Rescue Map design process began with acquisition of data and cartographic resources. Stakeholders then went through Design Criteria Interviews. From those interviews a Design Program emerged, and guided production of the Draft Map. The Draft Map was assessed in sessions that included a mock SAR scenario exercise, a questionnaire, and an interview. When the assessment was concluded, and the results analyzed, the Design Program was amended accordingly. There was some supplemental data acquisition from MMWD and then an Updated Map was produced. See the design process diagram in Figure 20.

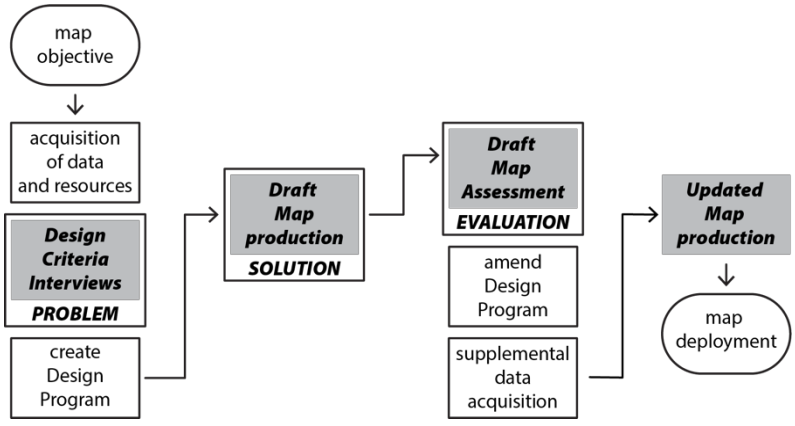


Figure 20: Design process diagram noting the problem-solution-evaluation cycle highlighted by Kveladze, et al.

3.1. Acquisition of Data and Cartographic Resources

MMWD provided a geodatabase of roads and trails that had been maintained for over 15 years. The data is extensive, well-organized, and the meta-data is well-conceived and provides clear information about each field. See Appendix B for MMWD roads and trails geodatabase metadata. Additionally, MMWD did additional work, providing multiple updates to this geodatabase during Spring 2018.

3.2 Design Criteria Interviews

Needs and biases of the stakeholders as well as critique of the 2011 MMWD SAR map was garnered from the Design Criteria Interviews. The Design Criteria Interviews identified cartographic problems. The data from these interviews is analogous to the problem phase in the process used by Kveladze, et al.

3.3 Design Program

The responses to the Design Criteria Interviews were compiled, and emergent patterns were noted. These patterns informed the Design Program to guide production of the Draft Map.

3.4 Draft Map Production

Production commenced using a combination of ArcMap and Adobe Illustrator. Analysis was done in ArcMap and maps were exported as vectors to Adobe Illustrator where the production work was done.

Production of the Draft Map is analogous to the solution phase in the process used by Kveladze, et al.

3.5 Draft Map Assessment

The Draft Map was assessed for usability based on the professional experience and judgement of 11 respondents, all experienced with using maps and Marin County SAR. Respondents were given the objective of the assessment along with a working definition of usability. (Figure 21) The assessment sessions provided data analogous to the evaluation phase in the process used by Kveladze et al.

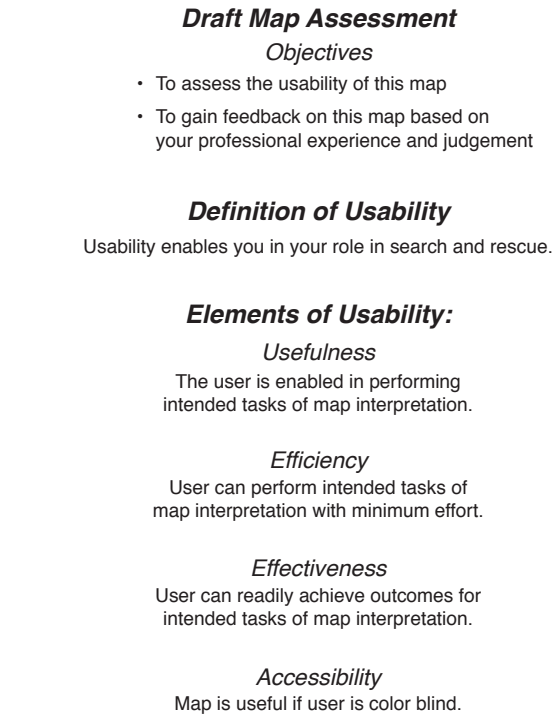


Figure 21: Statement of objective and a working definition of usability provided to respondents to the Draft Map Assessment. The working definition of usability was adapted from Rubin and Chisnell (2008).

The sample for assessing this particular map has unique constraints on it. The map contains confidential information that cannot be shared with the general public. When in use this map will ultimately be seen by approximately 30-40 people, primarily from within MMWD and MSAR.

The purposive sampling employed in this assessment was a non-random selection of respondents. The results were not guided by theory and were not able to be applied to measures of central tendency. There was no minimum number of respondents. Respondents were chosen for their knowledge, and their willingness to share their knowledge (Lewis & Sheppard 2006, Tongco 2007, Bláha 2009, Permani 2015). The respondents have expert familiarity with MMWD and SAR. The subjective needs and opinions of these experts provided context during analysis of the assessment data. It was also held that the respondents have biases that result from time, place, social environment, abilities,

knowledge and other variables of one's worldview. Analysis required incorporating respondents' opinions in the context of their biases (Bláha 2009).

Everybody who participated in this project has a professional stake in SAR on MMWD, has signed a Non-Disclosure Agreement, or is otherwise approved by the District to view the map and confidential assessment materials. The result is a select group of respondents who have familiarity with the area depicted on the map and are high-level SAR volunteers or professionals.

Procedure

The framework for the sessions was in three parts; a brief exercise to allow the respondents to use the map for an intended purpose; followed by a brief questionnaire; followed by an interview. See Figure 22 for a list of materials each respondent used in the Draft Map Assessment.

Materials received by each respondent for the Draft Map Assessment.

- Draft copy of MMWD Mt. Tamalpais Watershed 2018 Search and Rescue Map, 24″x36″
- Statement of objective and definition of usability
- Exercise Scenario and Instructions
- Questionnaire booklet

Figure 22: Materials received by each respondent for the Draft Map Assessment

This format allowed respondents to consider the cartography one time privately during the exercise. Then another time privately but with a public reveal, responding to questions and problem statements in the questionnaire. Finally, there was a third pass through the issues in the interviews which is a public expression of thought.

Exercise

The exercise provided a scenario with a set of clues about an MP followed by 10 instructions, such as "Area Search West of Sky Oaks Rd bordered by Bullfrog Fire Road and Meadow Club Fire Road up to Fairfax-Bolinas Road." Respondents were asked to read through the instructions and to manually draw polygons on the map in the locations indicated by the instructions. The exercise was timed at 10 minutes long.

The objective of the exercise is not to determine if the respondents can find the locations from the instructions, but rather it is having them go through a cognitive interaction with the cartography by completing intended tasks.

See the text of the exercise in Appendix C.

Questionnaire

Once the exercise was completed, focus shifted to the questionnaire for a timed 10 minutes. The first part gathered user background information in short written answers. about what their role in SAR is; how they will use the map; what their level of familiarity is with the area on the map; and if they are colorblind.

The second part of the questionnaire presents problem statements written simply, involving the cartography on the Draft Map. The problem statements probed issues such as eyeball movement, how much the respondent had to look back-and-forth between map and legend; and symbols, ease of comprehension, and whether they had an intuitive nature; and the success or failure of the graduated circle symbols used to represent parking. They rated their responses on a scale from "not at all…" to "neutral" to "very…".

See the questionnaire in Appendix D.

Interview

Following the private realm considerations during the exercise and the questionnaire, the interview was a public expression of thought. The interview had a semi-structured style. Reviewing cartography does lend itself to use of a checklist (Field 2012). However, participants come from a variety of backgrounds (law enforcement, fire protection, cartographic technology, among others) and there are likely a variety of approaches to how items on a cartographic checklist are met. See Figure 23 for the topics covered in the interview. The responses were allowed to wander, allowing respondents to go beyond basic answers, to talk more about their particular use of maps and what they wanted out of the

Updated Map. The interviews were timed at 20 minutes with flexibility. See the script used in these interviews in Appendix E.

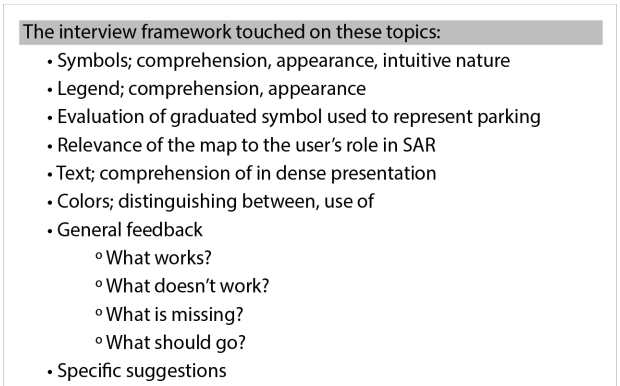


Figure 23:Topics in the interview framework

Note-taking was backed up with audio recordings of the sessions. The recordings are not documentation of the conversations per se but were made for purposes of being able to readily review what was said and to ensure that all commentary was included in the compilation. Each contribution was reviewed for incorporation into the amended Design Program.

3.6 Design Program Amendment

The Assessment informed the amendment of the Design Program. Responses were compiled into lists of words and phrases which were analyzed for common themes and singular relevance among them. The Design Program was amended with ideas from the Assessment that appeared to move the Updated Map product in the direction of meeting the needs of the audience.

3.7 Updated Map Production

The analysis that led to the Amended Design Program became a visual exercise when elements were tried graphically on the map during production. Production led to a "final" version of the Updated Map. That final version will undergo some minor tweaking to further meet the needs of the audience.

4.0 Development of the Map

This section provides additional detail about development of the map from the beginning of the project up to production of the Draft Map. These early steps in the project are briefly summarized in section 3.1 through 3.4.

4.1. Data and Cartographic Resources

MMWD Data

In order to explore classifying the roads and trails data into approximately five classes that would translate into line symbols on the map, analysis among the attributes in Figure 24 was attempted. However, this problem of classification was not that complex. Simply, the attributes of "abandoned," "system," "non-system," and "2WD" were used in the early versions of the Draft Map. Rangers Cerkel and McConneloug provided additional information to fine tune the classifications on the Updated Map.

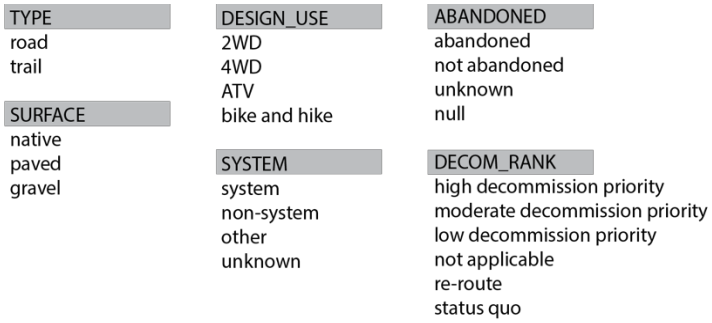


Figure 24: Fields and attributes from MMWD roads and trails geodatabase metadata

Additional data for utility lines, gates, culverts, and road markers was weighed for possible inclusion in the Updated Map. The utility line and gates data were included, but the culverts and road marker data were not. The culverts and road marker data sets are extremely dense and concentrated along the roads and trails. After inserting them into the map it was obvious that they would obscure the roads. Additionally, it is doubtful that specific information about each of these points could be conveyed at 1:18,000 scale.

A second MMWD data set (supplied by Ranger Matt Cerkel) improved on the initial roads and trails geodatabase. Cerkel updated trail names, added points of interest, historical sites,

and associated names using the app Avenza. Cerkel's data was incorporated into the GIS on 22 February 2018.

Cerkel's data in combination with the roads and trails geodatabase acquired from MMWD became the "latest and greatest" for roads, trails, points of interest, historical sites and place names, for the purposes of this project. The inclusion of Cerkel's data on the map added considerable content and historical perspective to the map.

Classification and nomenclature for roads and trails for this project was adopted in a meeting with MMWD Rangers on 14 March 2018 for use on the Updated Map. See Figure 25.

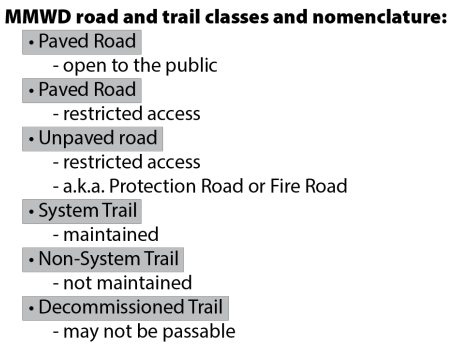


Figure 25: Road and trail classes and nomenclature

Among the historical sites in Cerkel's data are sites of airplane wrecks and a mine shaft on Mt. Tamalpais. MMWD has strict policies about not disseminating this information. Some of these sites are historically significant, and as long as most people believe their existence is more fable than fact, they will only be looted by the very knowledgeable or the very determined.

4.2. Design Criteria Interviews

The Design Criteria Interviews were about cartography. They posed specific questions about elements of the 2011 map (e.g. design of the scale bar and representation of the graticule). There were also questions about cartographic technique (e.g. graphic distraction,

color, clarity of the symbols, and figure to ground relationship), and about message (e.g. specific SAR themes).

In the course of these questions, the respondents were asked to consider some of the same things more than once in hopes that multiple passes by the same points would broaden their thinking, allowing them to access greater insight with each time.

Following are the questions from the Design Criteria Interviews with summarized responses and some analysis. See the script for the Design Criteria Interviews in Appendix F. For a more complete understanding of the responses to these interviews see the compiled responses in Appendix G.

Question 1: What on the map works?

When respondents were asked what themes they most often referred to, most of the information on the map was mentioned (e.g. applicability to SAR, parking, and roads and trails were among 16 types of information) were mentioned. The symbols and text in the legend were viewed as being of sufficient size and logically composed. The readability of symbols was referred to as "reasonable." Other elements that respondents felt were successful were the representation of the base information using streams, hillshade, and contour lines. The three shades of green representing the patrol areas on the District successfully highlighted the watershed lands from context.

Respondents seemed to think that the information on the map was relevant.

Question 2: What elements make the 2011 map a SAR map?

The universal answer to this question was the inclusion of the non-system trails.

Question 3: What on the map does not work?

The most significant elements of the map that were critiqued were the overwhelming appearance of the solid green polygons representing the patrol areas (the solid green color visually drowned out the contour lines) and the lack of contrast used to highlight the different kinds of road and trails.

MSAR Search Managers commented that the topographic information and the underlying hillshade were not necessary. Their greatest need was fully labelled, up-to-date information for roads, trails, and points of interest. That was viewed as a valuable layer in the SARTopo scheme.

Question 4: What improvements to the map can be made?

The passage of time and technological evolution since production of the 2011 map yielded new, improved data. The Updated Map has many more place names on it thanks to the dogged research of MMWD Ranger Matt Cerkel.

4.3 Creation of Design Program

The Design Program emerged from analysis of the Design Criteria Interviews and guided production of the Draft Map. The Design Program is shown in Figure 26.

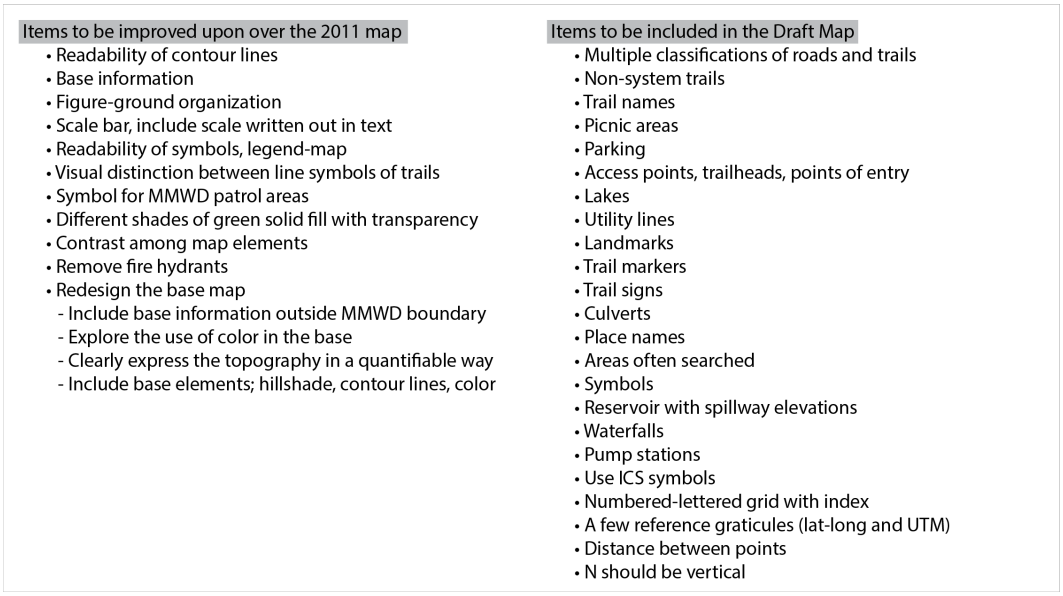


Figure 26: The Design Program, criteria that emerged from Design Criteria Interviews

4.4 Draft Map Production

Following creation of the Design Program, the elements of the program were put into the map during production. While everything in the program was attempted on the Draft Map,

not all of the elements ended up being included. This is reflective of the process of selection of the map maker, as is seen down the left side of Figure 16, Board's Map-Model Cycle.

Production work was done with ArcMap (analysis) and Adobe Illustrator (art work). Examples of analysis done in ArcMap are classification of roads and trails, creation of contour lines, and hillshade. The five different classes of lines in ArcMap were selected from MMWD data by attributes and exported to their own shapefiles. The 25-foot contours were derived from National Map DEM data using ArcMap. Index and interim contours were then selected by attributes and exported each to their own shapefiles.

Export of analysis from ArcMap was done using "Export Map…" which allows line work to be exported as vectors for Adobe Illustrator. Exports were done using the same neatline in a page view locked at locked at 1:18,000 scale. This neatline allowed easy registration of maps in Adobe Illustrator.

5.0 Results

The Draft Map Assessments took place during a one-week period in March 2018. Six test sessions were conducted, four individually and two in groups. one group had four individuals and one had three. The test sessions were between 30-90 minutes in length. See session details (dates, participants, locations and length) in Appendix H.

5.1 Assessment of Draft Map, Part 1: Scenario Exercise

In the scenario exercise respondents drew on the maps, marking locations indicated by the instructions. The responses to the exercise were not evaluated as part of the Assessment. The time spent responding to the instructions in the exercise was designed as an opportunity for respondents to execute cognitive tasks involving the cartography. The interaction between map and map user in the exercise gave respondents experience using the map as a warm-up before they answered subsequent questions in the questionnaire and the interview.

5.2 Assessment of Draft Map, Part 2: Questionnaire

Following are summaries of responses to the questionnaire. See a compilation of respondent background in Appendix I. See a graphical depiction of average responses to the objective portion of the questionnaire in Appendix J.

Respondent Background Summary

In addition to the project stakeholders there were additional MMWD Rangers, MSAR Search Managers.

The Rangers are out on MMWD every day they are at work. During SAR incidents they participate in hasty searches, overhead searches, and can take on the role of a SAR liaison or facilitator. They use maps to perform tasks such as establishing search areas, directing teams in the field, and passing on information about locations, landmarks and elevations. The Ranger respondents have an average 30 years of experience (with one outlier, a new member of the force) walking on the District both professionally and personally.

The MSAR Search Managers act in a volunteer capacity, and therefore come from various professional backgrounds–from construction contractors, to finance, to fire protection. They can participate in SAR as search managers, team leaders and general members of the MSAR team. They use maps to visualize strategy, produce pertinent maps, and to document ongoing searches. The average experience the MSAR manager respondents have of walking on the District is around 10 years with an outlier who grew up locally with great interest in the lands of the District. He has been walking the district, personally and professionally, for 38 years.

The stakeholder respondents are retired professionals who all worked on issues on MMWD. One as a GIS analyst for MMWD, one as a (contract) cartographer, and one as a fire chief. These respondents play no active roles in SAR, and two of the three have over 40 years of experience walking on MMWD.

None of the respondents reported being colorblind.

Objective Responses

The second part of the questionnaire presents problem statements written simply, involving cartography on the Draft Map with objective responses.

Response Summaries

Following are generalizations about the responses to each problem statement:

1. Respondents did not have to look back-and-forth between map and legend often.
2. Symbols on the map and in the legend appeared the same
3. The black-and-white square symbols were easy to understand.
4. Graduated circle symbols representing distribution of parking were not very useful, however, MSAR respondents found them to be more useful.
5. Distinguishing between the five different line symbols was very easy.

6. Black-and-white square symbols were not distracting to underlying and adjacent graphics. MMWD respondents found the marks to be more distracting and MSAR respondents found them to be less distracting.

7. Symbols on the map were relevant to the respondents' roles in SAR.

8. Regarding representation of the connection of roads and trails on MMWD to adjacent jurisdictions MMWD respondents found it to be less useful and MSAR respondents found it to be more so.

9. Labels on roads and trails were easily distinguished from labels for points of interest and historical sites.

10. Information (text, symbols, and associated leader lines) on the map in areas of densely packed information was very clear and legible.

11. Distance on the map could be estimated very easily.

12. The map and its design elements (line types, symbols, colors, text, and types of information) was very supportive of respondents' roles in SAR.

13. The map was perceived as a strong potential training tool.

14. It was easy to distinguish between colors on the map.

The final step in the Assessment was to rate four elements of usability; usefulness, efficiency, effectiveness, and accessibility. During the assessment, the respondents had three separate experiences considering the cartography at hand, the exercise, the questionnaire, and the interview. Rating these four aspects of usability was done last to serve as a summary the whole experience.

15. Respondents were enabled in performing intended tasks of map interpretation.

16. Respondents found that they could perform intended tasks of map interpretation efficiently, that is quickly with minimum effort.

17. Respondents found that the map was effective, that is that it enabled them in achieving outcomes for intended tasks of map interpretation.

18. This question regarding accessibility was irrelevant because none of the respondents reported color-blindness.

5.3 Assessment of Draft Map, Part 3: Interview

Following are summaries of responses to the interview questions. Interviews were semi-structured and varied in length from 20-90 minutes. See a compilation of what was said in the responses in Appendix K. Due to the semi-structured nature of the interviews there are points in the responses that are off topic.

How and when will you use this map?

Map used in everyday function of MMWD Ranger (on a mobile device, and as a paper map) in vehicle and on Ranger's person in the field. Could be used for training, as a paper map, ledger sized (11 x 17 inches, 279.4 x 431.8 mm) preferably. Distributed to searchers as letter-sized (8-1/2 x 11 inches, 215.9 x 279.4 mm) prints. This map would be a layer in SARTopo map output used to plan a hasty search, for example.

The map needs some tweaks, but it could be a relevant update to the currently used map.

<u>Legend and Symbols</u>

Tell me about the legend. How was the task of understanding the information in the legend and incorporating that information when you were looking at the map?

On point comments are summarized as follows: the legend was not an impediment to understanding the map; the symbols seemed standard, intuitive, and reference was not necessary; using picto-realistic symbols was viewed as positive; one respondent said they did not need to use the legend during the exercise.

Comments that went beyond the immediate scope of the question in conversation: some said they did not use the distance scale (a square mile and its fractions) or thought it was unnecessary; there were comments that there was too much information on the map, that simplifying the amount of information would be good; conversely, some information that had not been on readily available maps was seen as interesting or significant.

Particularly significant was the call for locating the fixed ICP locations, and to make routes that are not paved roads in red. The red symbol had been used on Marin County SAR maps in the past.

How about the symbols themselves? Do they appear different or the same in the legend and on the map?
Symbols appear the same.

How intuitive or not intuitive did you find the meaning of the symbols to be?
The meanings were intuitive. Also, the symbol for dam and water tank were not clear.

Tell me what you think of the circles used to show the distribution and capacity of parking on the district.
The circles were described as useless, unnecessary, distracting, too much information, and should be removed. Critical feedback was that they need to be lightened, contained too much brown, that the larger symbols should be removed.

It was noted by the MMWD Rangers that they already know the parking information and don't need it on the map. It was noted by MSAR Search Managers that noting parking at turnouts or other places where there is not a parking lot is helpful.

Will you use that information in your role?
MMWD Rangers said no, MSAR Search Managers said yes.

Why or why not?
No responses were given to this question.

There are five different line types (width and dash pattern) for five different kinds of roads and trails. Tell me about your experience in telling them apart.

Line symbols did not distinguish well. Respondents advocated for use of the color red for roads and trails, as it has been successfully used previously on Marin County SAR maps. It was noted that that trails are dense, complicated and crowded in some places, that the primary trails are not represented well, and that non-system trails could not be recognized. Roads should be dashed. Trails should be dotted. The abandoned trail symbol is good as is. Paved roads with restricted access should be shown differently from paved roads with public access. Differentiate roads subject to winter closure.

Comments beyond the immediate scope of the question: Matt Cerkel has the best awareness of non-system and abandoned trails on the District. Trail nomenclature: road, primary–paved road open to the public; road, secondary–unpaved road, restricted access, aka protection road; system trails–maintained; non-system trails–not maintained; abandoned trail–decommissioned, may not be passable.

Some symbols are designed to stand out more than others. Can you point to two (or maybe more than two) different symbols that stand out well?

Lakes, creeks, paved roads, picnic, parking, boat ramp, water, roads, parking, ranger stations, creeks, contours (could even be backed off a little bit), geographic references, parking, picnic grounds, symbols in black squares

Comments beyond the immediate scope of the question: include seasonal and year-round designations to stream symbols.

To take that idea a step further, can you point to two (or more) different kinds of symbols that do not stand out?

Spring, bridge (lines not heavy enough), dirt roads, hiking trails, dam (too much, symbol not necessary), fire station (use the fire engine from a road sign for fire house ), trail names, fire roads (should be red, solid).

Are symbols that do not stand out still understandable, or not understandable?
The water tank should be changed (do not use the "W" in black square, do not include spring-fed or pumped designation, make it a cylinder), and otherwise symbols stand out well.

Why?
Because when a symbol does not stand out more work is required to understand it.

Are the symbols used on the map relevant to your role in SAR?
Yes, particularly in that the map has place names and locations that were previously not seen.

Comments beyond the immediate scope of the question: discussion about availability of water, presumably for fire protection, but that it is not relevant to SAR.

Is there information that should appear as symbols that is not currently symbolized on this map?
Ranger houses, ICP locations, groundcover (brush, grass, marsh, granite, tree canopy).

Comments beyond the immediate scope of the question: Trails should be in red, paved roads in black.

Text
There are places on the map where the information is very dense. Some examples of this are: Deer Park School to Lake Lagunitas and Phoenix Lake; and at various places on the flanks of Mt. Tam. In these areas the density of information on the map is increased by things like leader lines that are longer, text in all-caps closely alongside text that uses lower case, and in some instances, I had to use two different text sizes (one being small, the other being tiny) to label information in impacted areas. Tell me about grasping the information on the map in these areas.
Trail text labels are going to be tight, that is the nature of the configuration of the trails on the map. Reduce the size of the trail text labels to 6-point font.

Comments beyond the immediate scope of the question: Leader lines from label to trail are effective.

Is it difficult or easy to read?
It is challenging to read the text. Perhaps masking behind the text could be used.

Comments beyond the immediate scope of the question: Where leader lines are used, they are too thin.

Colors

Are you able to see colors on this map?
Yes.

If you are colorblind, can you tell me about the colors you can and cannot see? Can you point out features on the map that you have a hard time distinguishing because of color?
One respondent noted the that the blue used to symbolize water was difficult to see.

Do you have any guidance for me as I try to produce a map that is accessible in this way?
Use colors. Do not worry about the color-blind population. Text should be black.

General Feedback, Critique, or Input

Do you like this map?
Yes.

What do you like?
Elements respondents liked: size of the map, orientation, colors, fade just beyond MMWD boundary, composition of page, the amount of information on the page, scale, easy to read, the new information (points of interest, historical sites, abandoned, and non-system trails, place names, social trails, airplane wrecks, things that are attractive nuisances), leader lines

help to clear out areas crowded with information, interest has been brought to the map. “I like all maps. I’m a map guy.”

What don’t you like?

Lack of connection to adjacent jurisdictions; not much contextual information off the watershed; hard to distinguish the trails and the contour lines; fire roads don’t stand out from regular trails; north is not quite vertical (however, maps printed out of SARTopo are going to be north-vertical); no latitude-longitude on map.

Are there things that should go?

Graduated circle symbols representing parking (get rid of them or make them smaller); Pine Mountain Tunnel; MMWD administrative boundary (remove the dashed line, leave the wide line with transparency); dam symbol; the spring-fed v. pumped in water tank symbol; airplane wreck symbol; symbols are too numerous; square area scale; legend is too big, too much information.

Comments beyond the immediate scope of the question: include information for culverts and road markers.

Are there things that are not included but should be?

Symbol for ranger residences; water tank on Shafter Grade; label for Oak Tree Junction near Six Points; pipeline bridge over trail, 40-50 ft. off the ground from Eldridge Grade to Windy Ridge/Indian Fire Road; gates; locked gates; lat-long grid; UTM grid

Do you have any specific suggestions the final version of this map is produced?

Respondents provided a long list of thoughtful and pertinent suggestions. The list in its entirety is important to the project. See the list of compiled responses in Appendix K.

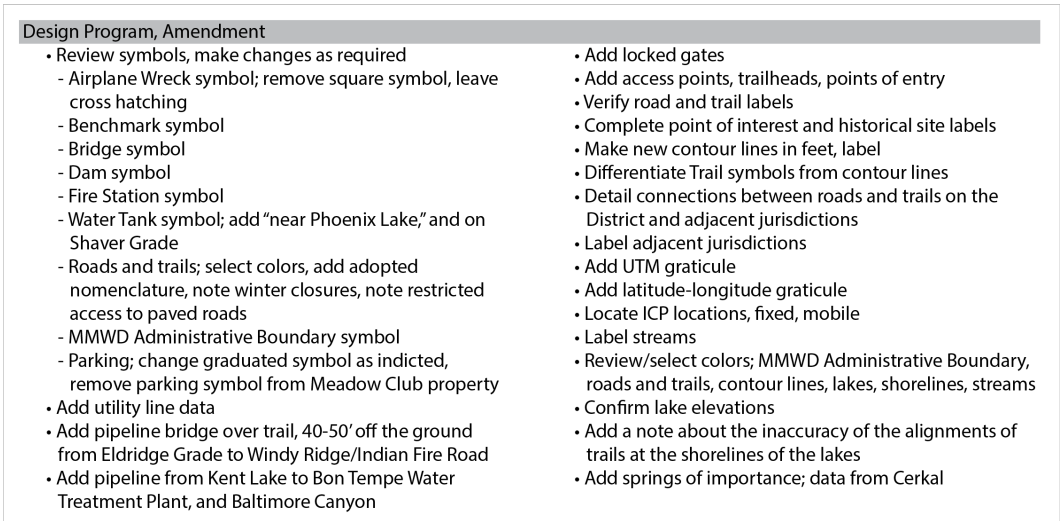
You can write any additional thoughts or suggestions on the back page of the pamphlet under “Do you have any specific suggestions for this map?”

Again, see the list of compiled responses in Appendix K.

These accounts were taken from audio recordings of the Draft Map Assessment Interviews. They are very close to exactly what was said. Chapter 6 examines this feedback and identifies changes to the map that resulted in the Updated Map.

5.4 Amendment of Design Program

The original Design Program was amended after analyzing the results of the Assessments. See the Amended Design Program in Figure 27.



Design Program, Amendment

- Review symbols, make changes as required
  - Airplane Wreck symbol; remove square symbol, leave cross hatching
  - Benchmark symbol
  - Bridge symbol
  - Dam symbol
  - Fire Station symbol
  - Water Tank symbol; add "near Phoenix Lake," and on Shaver Grade
  - Roads and trails; select colors, add adopted nomenclature, note winter closures, note restricted access to paved roads
  - MMWD Administrative Boundary symbol
  - Parking; change graduated symbol as indicted, remove parking symbol from Meadow Club property
- Add utility line data
- Add pipeline bridge over trail, 40-50' off the ground from Eldridge Grade to Windy Ridge/Indian Fire Road
- Add pipeline from Kent Lake to Bon Tempe Water Treatment Plant, and Baltimore Canyon
- Add locked gates
- Add access points, trailheads, points of entry
- Verify road and trail labels
- Complete point of interest and historical site labels
- Make new contour lines in feet, label
- Differentiate Trail symbols from contour lines
- Detail connections between roads and trails on the District and adjacent jurisdictions
- Label adjacent jurisdictions
- Add UTM graticule
- Add latitude-longitude graticule
- Locate ICP locations, fixed, mobile
- Label streams
- Review/select colors; MMWD Administrative Boundary, roads and trails, contour lines, lakes, shorelines, streams
- Confirm lake elevations
- Add a note about the inaccuracy of the alignments of trails at the shorelines of the lakes
- Add springs of importance; data from Cerkal

Figure 27:Amended Design Program

6.0 Discussion

6.1 Usability of Cartography for SAR on MMWD

The usability of the Updated Map, the MMWD Mt. Tamalpais Watershed Search and Rescue Map 2018, can be examined for its specific content, and for consideration of the needs of the users.

The specific content discussed here are elements of the Design Program, symbolization and color in particular. The Design Program was informed by specific comments in the evaluation-interview steps, comments such as “too much brown,” or “remove the big symbols.” In the production steps, these comments became items in a list for inclusion or exclusion in the map.

User needs became clear when the data gathered in the evaluation-interview steps was analyzed as a whole. Constituencies with different needs emerged, even in light of the purposive sample that was used.

6.2 Evolution of the Design Program

The original Design Program evolved into the Amended Design Program as a result of analysis of data gathered in the Draft Map Assessment. All of the elements in the Design Programs were tried in the map. Due to the selective view of the real world and the mapping technique employed by the map maker only some of the elements remained in the map.

Symbols: Circle Symbols

Graduated circle symbols representing parking were included on the Draft Map. The reaction to them was split between the MMWD Rangers and MSAR Search Managers. Rangers indicated that they were unnecessary, while MSAR Search Managers thought they could be helpful.

From the map maker’s perspective, the circle symbols were not optimally applied to the Draft Map. There were two problems. First, the largest of the graduated circle symbols representing off-road parking were too large. These large circle symbols were among the

most significant symbols (Stachoň, et al 2016) on the map, that is they made other symbols appear secondary. Also, they were redundant. Black square parking lot symbols representing off-road parking lots were also present on the Draft Map. Circle symbols should have been used to represent roadside parking only.

Second, the circle symbols were graduated, meaning that the area of the circles was proportional to the values they represented (Brewer & Campbell 1998, Dent, Torguson & Hodler 1999, Meihoefer 1973). Values of graduated circles cannot be perceived by most map readers relying on visual inspection and comparison of relative sizes on a map (Meihoefer 1973). Range-graded circles are a better option to represent parking in this case, as quantities of roadside parking are divided into groups such as 2-5 spaces, and 6-25 spaces. An example of range-graded circles versus graduated circles can be seen in Figure 11.

On the Updated Map, roadside parking was represented by two range-graded circle symbols instead of graduated circle symbols. Parking lots were symbolized with the black-and-white square parking symbol as they were on the Draft Map.

Additionally, circle symbols function well visually because of their geometrically compact form and smooth edges (Dent, Torguson & Hodler 1999) when they are, for example, placed along a characteristically winding road such as Bolinas-Fairfax Road on MMWD. The winding configuration of closely placed circle symbols can be seen in Figure 11.

Symbols: Points of Interest

Some of the black square symbols used in the Draft Map proved to be not quite refined enough. Following Stachoň's Principle of Composition (Stachoň, et al 2016), symbols were designed to appear differently than the object or generalizations they represent. However, respondents indicated that symbols that are similar to the object they represent were more desirable. For example, on the Draft Map the water tank and fire station symbols were represented by the letters 'W' or 'F' in the black square as shown on the left side of Figure 28. In the case of the fire station symbol, it is likely that the letter 'F" in the black

square was not sufficient because of the background of the respondents. In the Draft Map Assessment Interviews, the symbol was characterized as not strong. A fireman among the respondents suggested using the fireman's badge as the symbol, which is a standard graphic representing the profession.

In the case of the water tank symbol, on the Draft Map the water tank symbol had the added dimensions of pumped and gravity fed. In the Draft Map Assessment Interviews, the added dimensions were critiqued as unrelated to SAR. Additionally, there was a comment "Why don't you use a simple cylinder as the symbol?" along with a sketch supplied by a respondent.

In both of these instances the symbols went against Stachoň's Principle of Composition. They changed to become symbols that appear similar to the objects they represent. It is possible that the use of a purposive sample (Lewis & Sheppard 2006, Tongco 2007, Bláha 2009, Permani 2014), which resulted in respondents with specialized views (bias) of things like fire stations and water tanks, is the reason for this result that goes against the Principle of Composition (Stachoň, et al 2016). Analysis of responses in the Draft Map Assessment Interviews required incorporating respondents' opinions in the context of their biases (Bláha 2009) resulting in these changes to the symbols shown in Figure 28.

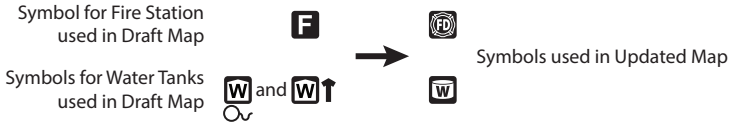


Figure 28: A graphical explanation of how the fire station and water tank symbols evolved from the Draft Map to the Updated Map.

Symbols: Roads and Trails

The visual distinction of the road and trail symbols was panned in the Draft Map Assessment interviews. On the Draft Map roads and trails all appear in black, using different widths and dash patterns to differentiate them. There was a repeated request by respondents for color–specifically, to use red for unpaved roads and trails discerned with different line widths and dash patterns. Paved roads (e.g. Bolinas-Fairfax Road, Sky Oaks Road, and Ridgecrest Boulevard) were to be black.

Red has been used to represent unpaved roads and trails on past SAR maps by Tom Harrison Maps. Part of the desire to keep this distinction is because it has been in use so long that it has become standard. An MSAR Search Manager also said that “what is in red is what we search.”

On the Updated Map, Primary Roads were differentiated from Secondary Roads and the classes of Trails using the colors red and black. Primary Roads were made black, Secondary Roads and Trails were made red. This is at least partially in keeping with Stachoň’s Principle of Significance, which is when primary objects are visualized more distinctly than secondary objects. In this case, the use of black and red has the effect of making the roads and trails visually distinct; however, primary and secondary elements are ambiguous depending on the level of zoom and what part of the map is being examined.

The clear distinction between the black roads and red roads and trails helped the aforementioned MSAR Search Manager to visualize areas (Wood and Brodlie 1994, Hallisey 2005) to be searched. Incorporating this analysis of respondents' opinions in the context of their biases (Bláha 2009) led to the change to using red and black as outlined to achieve distinction on the Updated Map.

In regard to classification and nomenclature of the roads and trails, the MMWD Rangers suggested using road and trail classifications from their operations management plan (MMWD 2005). In that plan, roads have five classifications, as do trails. Roads are classified with consideration of volume of use or whether they serve critical infrastructure. The classes in the 2005 Plan are based the roads’ need for maintenance, taking into consideration issues such as equestrian use, volume of use, importance to wayfinding on the District, amount of improvements (such as stairs, railings, walls, bridges, etc.) or if they have a backcountry character. Like the classes of roads in the plan, the trail classes address MMWD operations, and generally, the management plan addresses the MMWD mission. However, because this map is for SAR, which has different considerations than an operations management plan, the simpler classification of roads and trails was used.

The MSAR Search Managers did not have a problem with the classification of roads and trails on the Draft Map. The MMWD Rangers were largely in accord as well, although they suggested different nomenclature than what was in the legend on the Draft Map.

The map maker initially determined that five classes of roads and trails with associated line types would be the maximum number on the map. While the number did change to six, the visual distinction between the line types was attained. As more classes and types of lines are added, the scheme loses simplicity and the difference between line types on the map becomes less distinct. See the line types for the six classes of roads and trail in Figure 29.

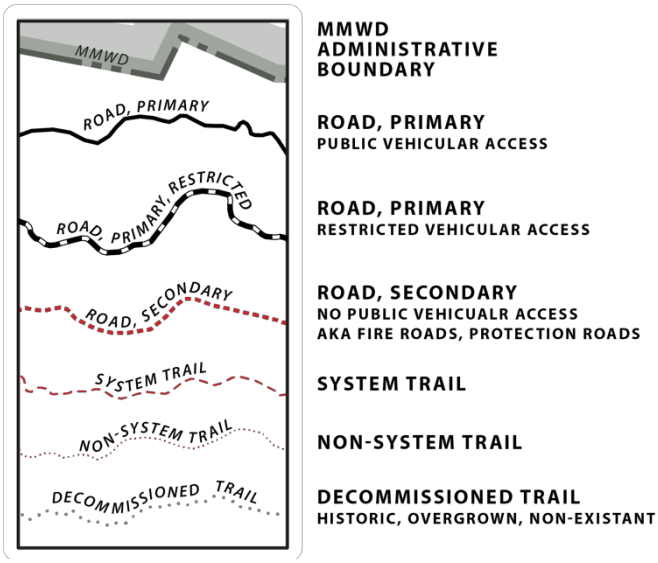


Figure 29: Road and trail classifications used on the Updated Map and associated line symbols

Color

On the Draft Map the design intent was to include minimal color, and to rely on contrast alone to differentiate elements. In the Draft Map Assessment there was a point about the ability to distinguish color because of concerns about the blue used to show streams and potentially labeling the streams in blue. Respondents were comfortable with use of color standards they had known from use of past maps.

Colors on the Draft Map were black, white, brown (used for contour lines, MMWD boundary, and circle symbols for parking), blue (used for lakes and streams), and red (used

for some roads, and trails). The brown contour lines and blue lakes and streams were created using the United States Geological Survey (USGS) specification, which is a standard.

Figures 30 and 31 show the specifications for symbols developed by USGS used for lakes, streams and contour lines (Federal Geographic Data Committee 2006). These are the colors used on the Updated Map.

Color: Lakes and Streams

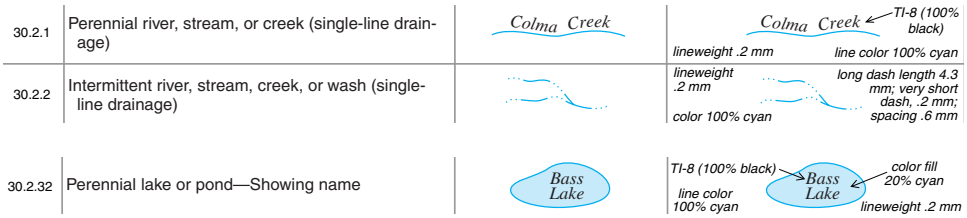


Figure 30: Specification for lakes and streams, USGS; a swatch of the CMYK color 100-0-0-0, for 100% cyan was created. That was turned into a global color, allowing percentages of the color to be used. A 20% version of the color fills the lake symbols. A 100% version of the color was used for shorelines and streams. (Federal Geographic Data Committee 2006)

Color: Contour Lines

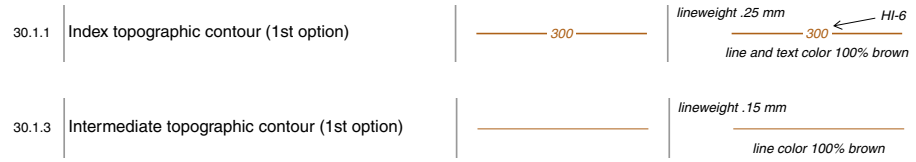


Figure 31: Specification for contour lines (Federal Geographic Data Committee 2006)

In Table 3 of the Federal Geographic Data Committee Digital Cartographic Standard for Geologic Map Symbolization, by USGS, brown is indicated as Pantone color 470U. Adobe Illustrator was used to convert this Pantone color to CMYK. The browns of the contour lines and the blues used for water symbols are shown in Figure 32.

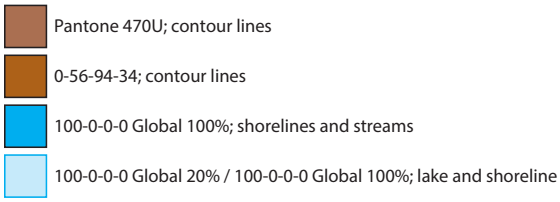


Figure 32: Colors from The Federal Geographic Data Committee Digital Cartographic Standard for Geologic Map Symbolization (Federal Geographic Data Committee 2006)

Color: Roads and Trails

The red used to represent Secondary Roads, System Trails, Non-System Trails and Decommissioned Trails on the Updated Map was taken from a capture of the Tom Harrison Maps SAR map used at SARTopo using the eyedropper tool in Adobe Illustrator. As a CMYK color it is 17-98-93-7. This color was chosen because respondents have familiarity with it from past maps.

The symbols and colors noted in this discussion have gone through the problem-solution-evaluation cycle (Kveladze, Kraak & van Elzakker 2013). The objective is that these elements on a map together enable visualization (Wood and Brodlie 1994, Hallisey 2005) making this map useful (Rubin & Chisnell 2008).

6.3 User Needs: MMWD Rangers Versus MSAR Search Managers

When trying to interpret the results of the Draft Map Assessment it is helpful to consider the respondents. Both MMWD Rangers and MSAR Search Managers are highly trained and carry out highly effective search operations. Institutionally, each exists in their own ecosystem, the Rangers within the agency of the water district, and MSAR within the agency of the County Sheriff. They are also rehearsed and very effective at working together. They play different roles operationally on a search, and they come to the search each with their own institutional culture.

From the first moments after an MP report, MMWD Rangers are in the field searching or directly facilitating others in a hasty search. They are always on patrol and have among the best knowledge of the roughly 19,000 acres of land that makes up the Mt. Tamalpais Watershed of MMWD. The tasks performed in the first operational period (Hill 1998,

Koester 2008) of a search are well-rehearsed. MMWD Rangers have performed these tasks many times. They also have experience with various subject categories of lost person behavior. Given clues and information of a case they know where and how to search during the important first operational period.

If a case grows to involve MSAR, search managers are in the ICP working in the ICS organizational structure, analyzing information, synthesizing search strategy and presenting maps for field personnel. The complementary roles of the two groups, MMWD Rangers and MSAR Search Managers, became apparent in the Draft Map Assessments.

MMWD Rangers: Tactical Use of the Map

There was one Ranger among the assessment respondents who regularly carries two or three different maps of the District, each map for particular qualities. In one case he may need a strong topographic map, in another he may need to know what the published Visitor's Map looks like, in yet another situation he may need to know the non-system trails in an area. The tasks for which MMWD Rangers will use this map are tactical, operational. Using MacEachern's three-dimensional "space" of map use (Figure 19) as a conceptual guide this involves performing analysis in the private realm, looking for unknown relationships among known information. The map user may be trying to answer questions such as "what is the shortest route?" or "what would be the best place for…?" (MacEachren & Kraak 1997). Map interactivity can easily be confused with technology. Interactivity is about direct interaction of a product and a user. Functionality relates better to technology, that is the ability to perform a certain function (Štěrba, Šašinka & Stachoň 2014). When an MMWD Ranger is in the field looking at a paper map or a map displayed on a mobile device s/he can have higher interaction with either format. However, the functionality of the paper map is limited while the functionality of the mobile device may be broader, allowing functions such as pan and zoom.

MSAR Search Managers: Strategic Use of the Map

MSAR managers use maps like detectives, leveraging data that is gathered during an incident, working through clues. As an example, in the course of a search in 2014 (the first

use of SARTopo by MSAR) initial clues pointed to an MP being on Mt. Tamalpais. Days of searching by approximately 100 field personnel turned up nothing. During an off-day for field personnel, a Mattson was performed and there was a credible sighting of the MP. When another day of searching resumed, the case remained unresolved. At this point, another credible sighting was revealed, and the trail-centric search tactics shifted to searching off-trail using tight grid search patterns in very steep, rugged terrain covered in dense vegetation. The MP was found deceased after ten days of searching. See a map of the search tracks recorded during this incident in Figure 33.

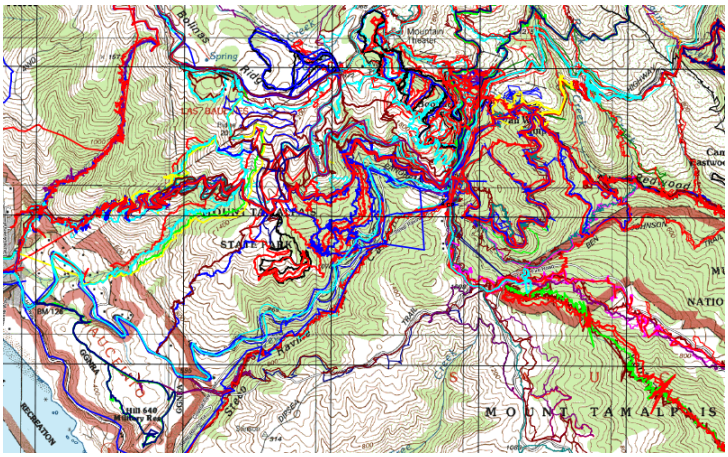


Figure 33: Search tracks from an MP incident on Mt. Tamalpais.

In this example, MSAR Search Managers are synthesizing from groups of investigative results. In a Mattson, all principals in a search are polled in order to rate segments of the search area for POA (Probability of Area), which describes the chance of the MP being in a segment of land under consideration (Koester 2008). What each principal is bringing to the Mattson is known. Each principal has been developing their thought, probably through multiple operational periods of the search. When each of the principals contribute what they know, new information can be synthesized. Questions such as “how different are multiple solutions?” or “how can we best summarize many, perhaps conflicting, results?” (MacEachren & Kraak 1997) contribute to this synthesis. Results of a Mattson reveal unknowns in a more public realm than the analysis described from during a hasty search.

The MMWD Rangers and the MSAR Search Managers will have different needs when looking at the Updated Map. MMWD Rangers will use it often and on an ad hoc basis. MSAR managers will use it as a layer in SARTopo to provide place names to routes, points of interest, and historical sites as they perform analysis, synthesize and present information about an MP incident.

Circle Symbols

The difference in how Rangers and MSAR Search Managers will use the map was also made clear in conversation regarding circle symbols used to represent roadside parking. Rangers advocated for no roadside parking symbols. In the interview, regarding the roadside parking symbols, they made points such as “Rangers already know that information,” “Information is unnecessary,” “Too much information,” “Remove the symbols,” and "Rangers know the capacity of the parking on the district, don’t need that information.” The Rangers were unanimous in their opinion that they would not use the information represented in their roles in SAR.

The MSAR managers took a more measured approach, advocating for removal of the largest of the circle symbols and symbolizing the roadside parking areas with smaller circle symbols. In the interview they indicated that “Noting parking at turnouts is helpful,” and that they would use this information in their roles in SAR.

Parking symbols on Bolinas-Fairfax Road near Cataract Trail and Alpine Dam were discussed with both Rangers and MSAR Search Managers. Roadside parking in that area is a good example of need for symbolization. Without the symbols the map does not clearly represent the real-world condition, that there is parking along the side of the road in that area. Without parking symbols in this area, the map user cannot rely on the information on the map to visualize (Wood and Brodlie 1994, Hallisey 2005), but instead is dependent on prior knowledge of the area. The Rangers likely do have that knowledge, the MSAR managers just might have that knowledge.

Base Information

Another area where the Rangers and the Search Managers expressed differences relates to the base information. The Draft Map has hillshade overlaying topographic isolines as base information. The Rangers had little commentary on the base information, as if it is a given that the information is on the map.

On the other hand, early on, in the Design Criteria Interviews, MSAR Search Managers expressed a preference for no base information on the map at all. This is because this map will primarily be used as a layer in SARTopo, where it can overlay any number of data sets as base information.

7.0 Conclusion

The SAR map for MMWD has been updated with locations and names of routes, points of interest, and historical sites using data collected since the 2011 MMWD SAR map. That additional data came from a geodatabase used in the roads and trails ArcMap GIS maintained by MMWD. Complete and well-organized metadata accompanied the geodatabase (See Appendix B). MMWD Rangers also contributed corrections and additions to the data for this update.

The two user groups in the audience of this map, MMWD Rangers and MSAR Search Managers, were found to use the map in different ways. MMWD Rangers patrol The District at all times with a broad mission of protecting and preserving the resources on MMWD while helping visitors. They have a very high level of specific familiarity with the land, with an affinity for locations from landmark trees and outcroppings to terrain of the trails and other little-known places and facts. Hence, when they use this map, they will be using it to confirm what they already know. The map will be secondary to knowledge they already have. Additionally, their interaction with the map will likely be in situ, informing tactical decision.

The geographic scope of the work of MSAR Search Managers is the entirety of Marin County and beyond in the case of mutual aid calls. Their expertise is more narrowly in SAR. When they use this map, it will be as a layer in the scheme of SARTopo in the ICP during an MP incident, and it will be an element in maps distributed to field personnel. During each incident MSAR Search Managers are looking at a unique situation with its own set of clues and information. Their tasks may include analysis, synthesis and presentation of information (MacEachren & Kraak 1997), visualizing (Wood and Brodlie 1994, Hallisey 2005) as they postulate about an MP's behavior (Koester 2008) or where they may be.

MMWD Rangers will benefit from a map that includes base information (topography and hillshade) to provide cartographic context to visual surroundings. MSAR Search Managers

will benefit from the Updated Map without base information that can be used as a layer with transparency in the scheme of SARTopo.

Two configurations of the map, one with base information, one without base information were delivered to the map users. Given a choice between these two maps, the users can maximize the usefulness, efficiency, and effectiveness with which they use the map.

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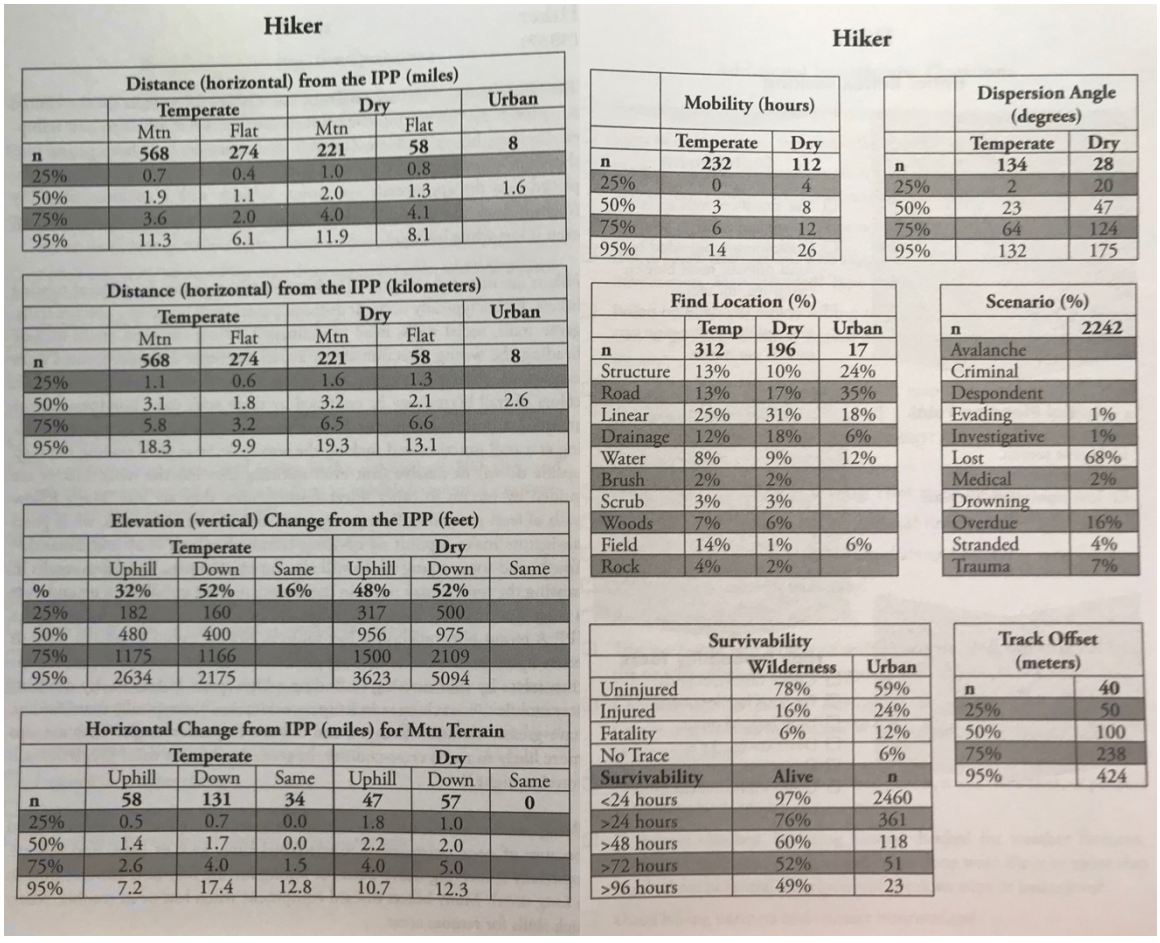
Appendix A

Examples of Statistics for Three Subject Categories

Following are statistics from past searches involving hikers, mountain bikers and subjects with mental illness. Subject categories contain statistics like these along with suggested initial tactics and suggested additional investigative questions which are also derived from past searches. These statistics are taken from the ISRID.

These images are taken from Koester, R. J. (2008). Lost person behavior. *A search and rescue guide on where to look–for land, air and water. 1st ed. dbS Productions LLC, Charlottesville, VA, USA.*



Hiker

Distance (horizontal) from the IPP (miles)					
	Temperate		Dry		Urban
	Mtn	Flat	Mtn	Flat	
n	568	274	221	58	8
25%	0.7	0.4	1.0	0.8	
50%	1.9	1.1	2.0	1.3	1.6
75%	3.6	2.0	4.0	4.1	
95%	11.3	6.1	11.9	8.1	

Distance (horizontal) from the IPP (kilometers)					
	Temperate		Dry		Urban
	Mtn	Flat	Mtn	Flat	
n	568	274	221	58	8
25%	1.1	0.6	1.6	1.3	
50%	3.1	1.8	3.2	2.1	2.6
75%	5.8	3.2	6.5	6.6	
95%	18.3	9.9	19.3	13.1	

Elevation (vertical) Change from the IPP (feet)						
	Temperate			Dry		
	Uphill	Down	Same	Uphill	Down	Same
%	32%	52%	16%	48%	52%	
25%	182	160		317	500	
50%	480	400		956	975	
75%	1175	1166		1500	2109	
95%	2634	2175		3623	5094	

Horizontal Change from IPP (miles) for Mtn Terrain						
	Temperate			Dry		
	Uphill	Down	Same	Uphill	Down	Same
n	58	131	34	47	57	0
25%	0.5	0.7	0.0	1.8	1.0	
50%	1.4	1.7	0.0	2.2	2.0	
75%	2.6	4.0	1.5	4.0	5.0	
95%	7.2	17.4	12.8	10.7	12.3	

Hiker

	Mobility (hours)	
	Temperate	Dry
n	232	112
25%	0	4
50%	3	8
75%	6	12
95%	14	26

	Dispersion Angle (degrees)	
	Temperate	Dry
n	134	28
25%	2	20
50%	23	47
75%	64	124
95%	132	175

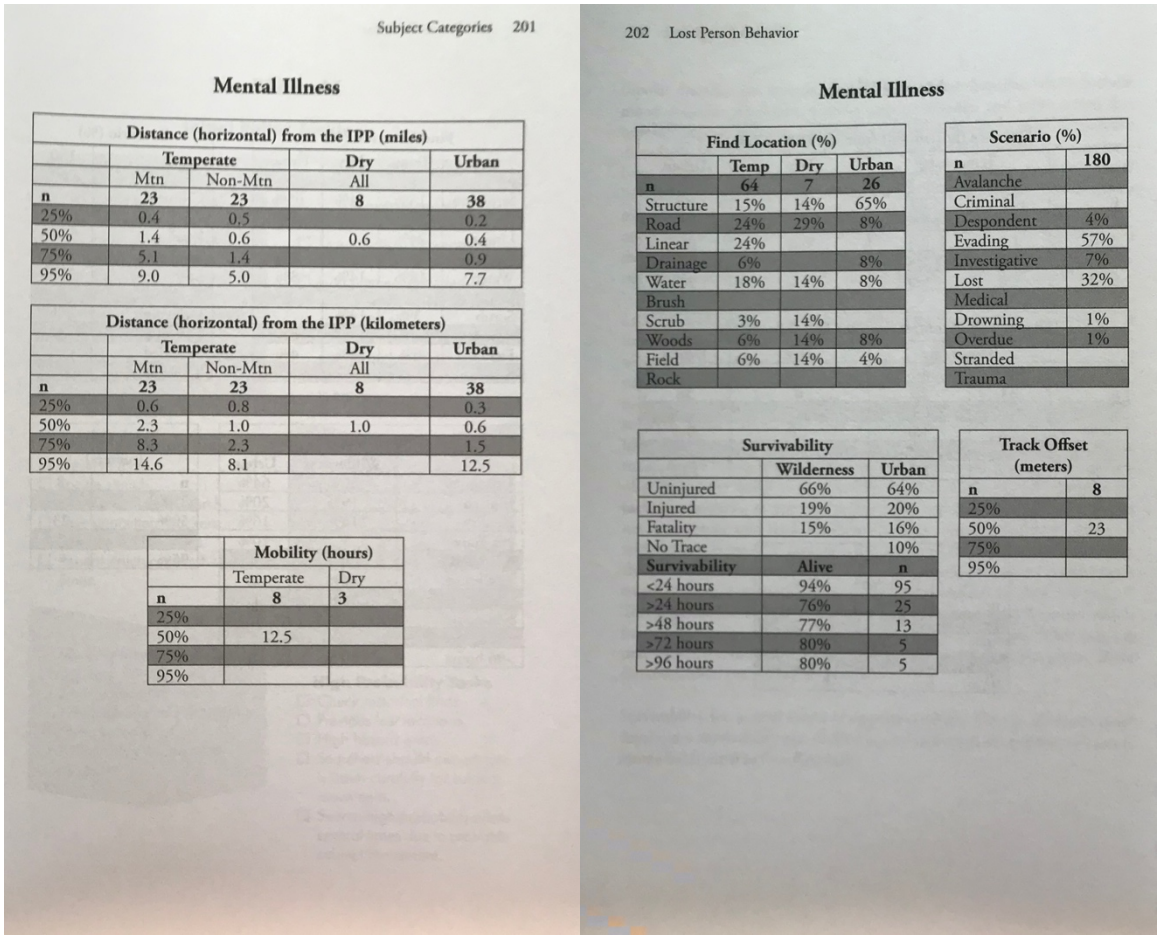
Find Location (%)			
	Temp	Dry	Urban
n	312	196	17
Structure	13%	10%	24%
Road	13%	17%	35%
Linear	25%	31%	18%
Drainage	12%	18%	6%
Water	8%	9%	12%
Brush	2%	2%	
Scrub	3%	3%	
Woods	7%	6%	
Field	14%	1%	6%
Rock	4%	2%	

Scenario (%)	
n	2242
Avalanche	
Criminal	
Despondent	
Evading	1%
Investigative	1%
Lost	68%
Medical	2%
Drowning	
Overdue	16%
Stranded	4%
Trauma	7%

Survivability		
	Wilderness	Urban
Uninjured	78%	59%
Injured	16%	24%
Fatality	6%	12%
No Trace		6%
Survivability	Alive	n
<24 hours	97%	2460
>24 hours	76%	361
>48 hours	60%	118
>72 hours	52%	51
>96 hours	49%	23

Track Offset (meters)	
n	40
25%	50
50%	100
75%	238
95%	424

Statistics from the hiker subject category



Subject Categories 201

Mental Illness

Distance (horizontal) from the IPP (miles)				
	Temperate		Dry	Urban
	Mtn	Non-Mtn	All	
n	**23**	**23**	**8**	**38**
25%	0.4	0.5		0.2
50%	1.4	0.6	0.6	0.4
75%	5.1	1.4		0.9
95%	9.0	5.0		7.7

Distance (horizontal) from the IPP (kilometers)				
	Temperate		Dry	Urban
	Mtn	Non-Mtn	All	
n	**23**	**23**	**8**	**38**
25%	0.6	0.8		0.3
50%	2.3	1.0	1.0	0.6
75%	8.3	2.3		1.5
95%	14.6	8.1		12.5

	Mobility (hours)	
	Temperate	Dry
n	**8**	**3**
25%		
50%	12.5	
75%		
95%		

202 Lost Person Behavior

Mental Illness

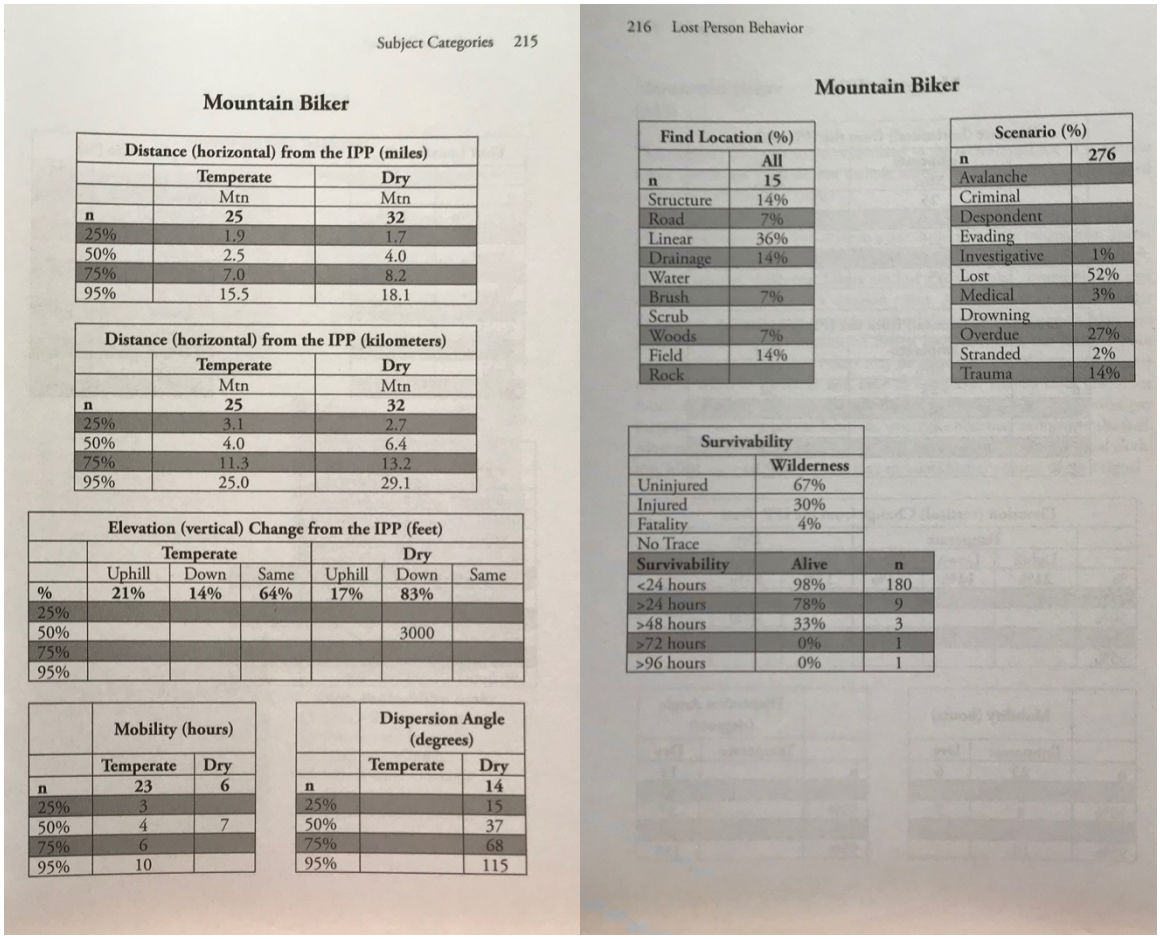
Find Location (%)			
	Temp	Dry	Urban
n	**64**	**7**	**26**
Structure	15%	14%	65%
Road	24%	29%	8%
Linear	24%		
Drainage	6%		8%
Water	18%	14%	8%
Brush			
Scrub	3%	14%	
Woods	6%	14%	8%
Field	6%	14%	4%
Rock			

Scenario (%)	
n	**180**
Avalanche	
Criminal	
Despondent	4%
Evading	57%
Investigative	7%
Lost	32%
Medical	
Drowning	1%
Overdue	1%
Stranded	
Trauma	

Survivability		
	Wilderness	Urban
Uninjured	66%	64%
Injured	19%	20%
Fatality	15%	16%
No Trace		10%
Survivability	**Alive**	**n**
<24 hours	94%	95
>24 hours	76%	25
>48 hours	77%	13
>72 hours	80%	5
>96 hours	80%	5

Track Offset (meters)	
n	**8**
25%	
50%	23
75%	
95%	

Statistics from the mental illness subject category



Subject Categories 215

Mountain Biker

Distance (horizontal) from the IPP (miles)		
	Temperate	Dry
	Mtn	Mtn
n	**25**	**32**
25%	1.9	1.7
50%	2.5	4.0
75%	7.0	8.2
95%	15.5	18.1

Distance (horizontal) from the IPP (kilometers)		
	Temperate	Dry
	Mtn	Mtn
n	**25**	**32**
25%	3.1	2.7
50%	4.0	6.4
75%	11.3	13.2
95%	25.0	29.1

Elevation (vertical) Change from the IPP (feet)						
	Temperate			Dry		
	Uphill	Down	Same	Uphill	Down	Same
%	**21%**	**14%**	**64%**	**17%**	**83%**	
25%						
50%					3000	
75%						
95%						

	Mobility (hours)	
	Temperate	Dry
n	**23**	**6**
25%	3	
50%	4	7
75%	6	
95%	10	

	Dispersion Angle (degrees)	
	Temperate	Dry
n		**14**
25%		15
50%		37
75%		68
95%		115

216 Lost Person Behavior

Mountain Biker

Find Location (%)	
	All
n	**15**
Structure	14%
Road	7%
Linear	36%
Drainage	14%
Water	
Brush	7%
Scrub	
Woods	7%
Field	14%
Rock	

Scenario (%)	
n	**276**
Avalanche	
Criminal	
Despondent	
Evading	
Investigative	1%
Lost	52%
Medical	3%
Drowning	
Overdue	27%
Stranded	2%
Trauma	14%

Survivability	
	Wilderness
Uninjured	67%
Injured	30%
Fatality	4%
No Trace	

Survivability	Alive	n
<24 hours	98%	180
>24 hours	78%	9
>48 hours	33%	3
>72 hours	0%	1
>96 hours	0%	1

Statistics from the mountain biker subject category

Appendix B

MMWD Roads and Trails Geodatabase Metadata

Field Name	Field Type	Field Description
OBJECTID_12		auto assigned by ArcGIS
NAME	text 50	primary name of route (will default to this one in ArcGIS auto labeling)
NAME_ALT	text 50	for use when a segment has two names (like when you can be on Hwy 1 and 101 at the same time)
ALIAS	text 50	for use when a segment is known by an old name, or when an unnamed, non-system trail has a "moniker"
CFCC	text 5	Census Feature Class Codes. Federal (US Census) codes used to describe a route's characteristic. For example, A10=interstate highway, A30=secondary road, A40=local road, A50=vehicular trail (aka dirt road), etc. see: http://www.census.gov/geo/www/tiger/appendxe.asc for the gory detail
OWNER	text 10	MMWD (Marin Municipal Water District), MCP (Marin County Parks), NPS (National Park Service), SP (CA State Parks), LOCAL (local government) or PRIVATE. Can also have combinations (e.g. MMWD-MCP). Note that this is assigned based in part on management practices. For example, many perimeter roads don't perfectly match the property lines, but MMWD manages one side and the adjoining owner manages (should manage) the other (see Bolinas Ridge, Worn Spring, etc.)
TYPE	text 5	Choose between "Road" or "Trail" only
SURFACE	text 10	Choose between "Native," "Paved," or "Gravel." (Strongly encourage choosing between one of these three, but I guess one could use "Other.")
CLASS	text 50	This is MMWD's "Internal Code" attribute, as used in other road datasets. Class I thru Class X, including "Gone" and "other." For the most part, "other" should be assigned to any features that are not MMWD's. From MMWD's Mt. Tamalpais Watershed Road and Trail Management Plan, 2005 see: http://www.marinwater.org/186/Roads-and-Trails, commonly referred to as the "RTMP."
DESIGN_USE	text 5	the type of traffic the road is designed or maintained for. Choose between "2WD, 4WD, ATV, Bike and Hike."
WTR_CLOSURE	text 5	Winter Closure. Choose between "Yes" "No" or "Maybe"
SP_DESGTN	text 15	Special Designation. Whether or not the route has a special designation, like the old RR routes or the Coastal, Bay, Ridge or Dipsea Trails, for example
FUEL_BREAK	short integer, precision=4, scale=0	Whether or not the route is identified in MMWD's Vegetation Management Plan as a Fuel Break. If so, the mid-range in fuel break design width is stated: Defensible Space = 200, Primary = 100, 2ndary = 75, and Ingress/Egress = 30.
VISITOR_MAP	text 5	Whether or not the route should be shown in MMWD's visitor map. Choose between "Yes" and "No" only. This field is also used to identify other official, or "system" routes, that are connections or extensions of the routes on MMWD land.
SYSTEM	text 5	Whether or not the route is an officially recognized route in MMWD's RTMP. Choose between "Yes," "No," or "Maybe." Use "Other" for non-MMWD routes.
ABANDONED	text 5	Whether or not the route has been abandoned, i.e. no longer maintained. Choose between "Yes," "No," or "Maybe." Okay to leave non-MMWD routes with NULL values.
DECOM_RANK	text 2	the decommission priority for each route. H = High, M = Moderate, L = Low, NA = Not Applicable, R = Reroute, SQ = Status-quo
SURVEYED	text 5	Whether or not the route has been on the ground surveyed. Choose between "Yes," "No," or "Maybe." Okay to leave non-MMWD routes with NULL values.
SURVEY_YR	short integer, precision=4, scale=0	what year the route was surveyed
METHOD	text 10	How the route was digitized. Choose between "Hand," "Ortho," "LiDAR" or GPS. If GPS, use the type of GPS unit used if known.
SURVEY_NEED	text 2	the priority of the route's need of a survey. H = High, HM = High-Moderate, M = Moderate, ML = Moderate-Low, L = Low, and NA = Not Applicable
PWA_SURVEY	text 5	whether or not Pacific Watershed Association (PWA) surveyed the route for erosion. Choose between "Yes," "No," or "Maybe." Okay to leave non-MMWD routes with NULL values.
FNCTN_LCTN	text 22	code used to link the route back to MMWD's SAP enterprise database. Okay to leave non-MMWD routes with NULL values.

Appendix C

Draft Map Assessment • Exercise

Scenario

- Car belonging to a 75-year old male found at Sky Oaks Lot at sundown. Car parked since 2pm yesterday.
- Physically fit hiker; knows the area
- Subject has early onset dementia symptoms that have worsened recently.
- No sightings in overnight hasty search.
- A full mutual aid search has been called in.

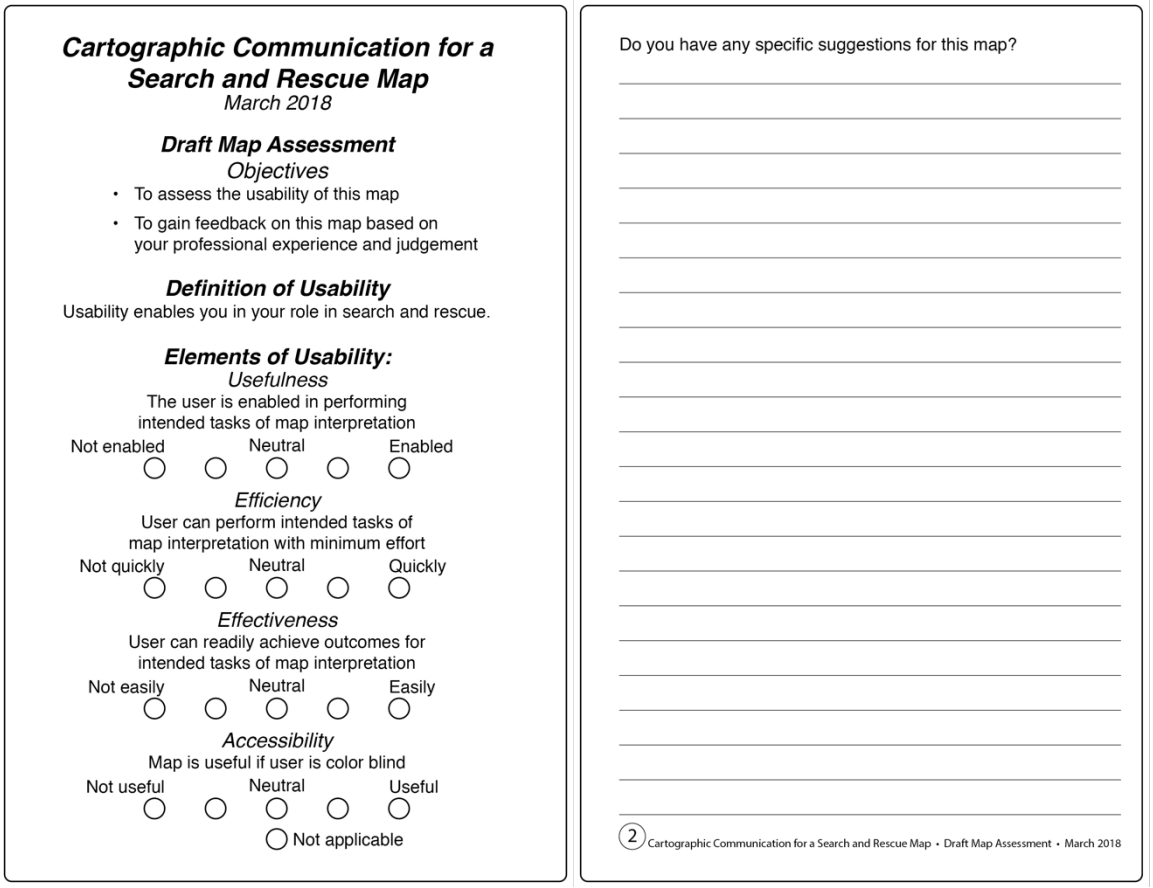
Search Instructions

- Area Search West of Sky Oaks Rd bordered by Bullfrog Fire Road and Meadow Club Fire Road up to Fairfax-Bolinas Road
- Search 50 yards both sides of Shaver Grade and Elliot Trail from Sky Oaks up to Five Corners
- Search 50 yards both sides of Taylor Trail
- Area Search W of Sky Oaks/BonTempe over to Bullfrog
- Hasty Search Kent Trail - Helen Markt Trail - Cataract
- Search Drainage along Canyon Trail to Woods Ln
- Search Drainage S of Elliot Trail and onto Phoenix Creek Drainage
- Hasty Search trail system around Bon Tempe Lake
- Hasty Search trail system around Lake Lagunitas
- Search Van Wycke Cr Drainage from Lake to 1600’ elevation
- Search E Fork Swede George Drainage to Kent Trail

Appendix D

Draft Map Assessment • Questionnaire

Design Assessment Questionnaire. (8-1/2” x 5-1/2” booklet, 8 pages) The first two pages of the booklet, which are the first pages below, were filled out last, at the end of the interview.



Cartographic Communication for a Search and Rescue Map
March 2018

Draft Map Assessment
Objectives
- To assess the usability of this map
- To gain feedback on this map based on your professional experience and judgement

Definition of Usability
Usability enables you in your role in search and rescue.

Elements of Usability:
Usefulness
The user is enabled in performing intended tasks of map interpretation
Not enabled ○ ○ Neutral ○ ○ Enabled

Efficiency
User can perform intended tasks of map interpretation with minimum effort
Not quickly ○ ○ Neutral ○ ○ Quickly

Effectiveness
User can readily achieve outcomes for intended tasks of map interpretation
Not easily ○ ○ Neutral ○ ○ Easily

Accessibility
Map is useful if user is color blind
Not useful ○ ○ Neutral ○ ○ Useful
○ Not applicable

Do you have any specific suggestions for this map?

2 Cartographic Communication for a Search and Rescue Map • Draft Map Assessment • March 2018

Circle one that applies to you

MMWD Ranger | MSAR | Other (please specify)

What is your role in SAR?

Describe how you use maps in your work with SAR.
Please give specific examples.

How many years have you been walking on the MMWD, both personally and professionally?

Are you color blind?
If so, which colors do you have a hard time distinguishing?

Additional responses

Optional
Would you be willing to follow-up with Mitch either on the phone or by email about any of your answers? If so, please provide your name, cellphone number, and email.

Name

Cellphone Number

Email Address

After a brief introductory period of time familiarizing yourself with the map, rate how often you needed look away from the map to use the legend in order to understand the symbols on the map, from not often to very often.

Not often ○ ○ Neutral ○ ○ Very often

○ No opinion

Rate the appearance of the symbols in the legend compared to the appearance of those same symbols in the map portion of the sheet, from appear exactly the same to appear very different.

Appear the same ○ ○ Variable ○ ○ Appear different

○ No opinion

Concerning the symbols composed of black and white graphics: Rate the ease of figuring out the meanings of the symbols, from very difficult to very easy.

Very difficult ○ ○ Neutral ○ ○ Very easy

○ No opinion

Rate the usefulness of the graduated-in-size circles that symbolize the distribution and capacity of parking on MMWD; from not useful to very useful.

Not useful ○ ○ Neutral ○ ○ Very useful

○ No opinion

Concerning the lines (various line widths and dash patterns) that represent roads and trails: rate the ease with which you were you able to distinguish between the five different types of roads and trails from very difficult to very easy.

Very difficult ○ ○ Neutral ○ ○ Very easy

○ No opinion

Concerning the symbols composed of black and white graphics with associated leader lines and text: Rate distraction caused by those elements to underlying and adjacent graphics, from not at all distracting to very distracting.

Not at all distracting ○ ○ Neutral ○ ○ Very distrating

○ No opinion

Concerning the symbols on the map: rate the relevance of these symbols to your role in search and rescue from not relevant to very relevant.

Not relevant ○ ○ Neutral ○ ○ Very relevant

○ No opinion

Rate the usefulness of detailing the map to show how roads and trails on MMWD connect to the roads and trails of adjacent jurisdictions and properties, from not at all useful to very useful.

Not at all useful ○ ○ Neutral ○ ○ Very useful

○ No opinion

Concerning the text on the map portion of the sheet: rate the ease with which you were able to distinguish between text labeling roads and trails and text labeling points of interest and historical sites, from very difficult to very easy.

Very difficult ○ ○ Neutral ○ ○ Very easy

○ No opinion

Concerning the labels on the map (text, symbols and associated leader lines): Rate the clarity and legibility of the information as it is affected by the density of information on the map portion of the sheet, from not clear and legible to very clear and legible.

Not clear and legible ○ ○ Neutral ○ ○ Very clear and legible

○ No opinion

Rate ease with which you were able to estimate distances on this map from very difficult to very easy.

Very difficult ○ ○ Neutral ○ ○ Very easy

○ No opinion

Concerning the design elements (i.e. lines, symbols, colors text, and types of information) as configured on this map: rate the support that you think the map will provide in your role in search and rescue, from not supportive to very supportive.

Not supportive ○ ○ Neutral ○ ○ Very supportive

○ No opinion

Concerning training a new person to perform your role in search and rescue: rate the strength of this map as a tool in such a training, from weak training tool to strong training tool.

Weak training tool ○ ○ Neutral ○ ○ Strong training tool

○ No opinion

Concerning the colors (blue for streams and lakes, and brown for topography and parking symbols graduated-in-size) on the map: rate ease with which you were able to distinguish features bearing these colors, from very easy to very difficult.

Very easy ○ ○ Neutral ○ ○ Very difficult

○ No opinion

Appendix E

Draft Map Assessment • Interview Script

Following is the script from the Draft Map Assessment Interviews.

1. Introduction (3 mins.)

1.1. Search and Rescue Map for the Lands of MMWD's Mt. Tamalpais watershed

1.2. Updating the last map which was produced in 2011

1.3. Objectives of the session today

1.3.1. To assess the usability of this map

1.3.2. To gain feedback on this map from you, based on your professional experience and judgement

1.4. Define usability

1.4.1. Usability enables you in your role in search and rescue

1.5. Elements of Usability

1.5.1. Usefulness

1.5.1.1. The user is enabled in performing intended tasks of map interpretation

1.5.2. Efficiency

1.5.2.1. User can perform intended tasks of map interpretation with minimum effort

1.5.3. Effectiveness

1.5.3.1. User can readily achieve outcomes for intended tasks of map interpretation

1.5.4. Accessibility

1.5.4.1. Map is useful if user is colorblind

2. Exercise (12 mins.)

2.1. Introduction

2.1.1. Please do not complete the bubbles on the front page for usefulness, efficiency, effectiveness and accessibility. I will ask you to do that as the last thing here today.

2.1.2. Also, the space on the back page of the pamphlet under "Do you have any specific suggestions for this map?" may be best used at the end of the session after you've thought about the content of this interview.

2.1.3. Additionally, you can write anything else in this space that either doesn't fit in the space provided, or that comes to mind as we go through this interview.

2.2. Respondents perform the exercise

3. Written questionnaire (10 mins.)

3.1. Re: legend

3.1.1. How often did you have to look back-and-forth?

3.2. Re: symbols

3.2.1. Do symbols in the legend appear the same or not the same as symbols in the map?

3.2.2. How well or poorly were you able to grasp the meaning of the various symbols?

3.2.3. Are the symbols easy or difficult to make sense of?

3.2.4. Are the graduated-in-size circle symbols for parking distribution effective?

3.2.5. Are symbols on the map a distraction to surrounding information?

3.2.6. Are the symbols relevant or not relevant to SAR?

3.3. Re: text

3.3.1. Discernment between words in all caps and words that use lower case

3.3.2. Label density on the map

3.4. Re: other

3.4.1. Importance of contextual roads/connection to roads

3.4.2. Ease of estimating distance

3.4.3. Map as training instrument

4. Interview (20 mins.)

4.1. How and when will you use this map?

4.2. Re: Legend and Symbols

4.2.1. Tell me about the legend.

How was the task of understanding the information in the legend and incorporating that information when you were looking at the map?

4.2.2. How about the symbols themselves?

Do they appear different or the same in the legend and on the map?

How intuitive or not intuitive did you find the meaning of the symbols to be?

4.2.3. Tell me what you think of the circles used to show the distribution and capacity of parking on the district.

Will you use that information in your role?

Why or why not?

4.2.4. There are five different line types (width and dash pattern) for five different kinds of roads and trails.

Tell me about your experience in telling them part.

4.2.5. Some symbols are designed to stand out more than others.

Can you point to two (or maybe more than two) different symbols that stand out well?

To take that idea a step further, can you point to two (or more) different kinds of symbols that do not stand out?

Are symbols that do not stand out still understandable, or not understandable?

Why?

4.2.6. Are the symbols used on the map relevant to your role in SAR?

Is there information that should appear as symbols that is not currently symbolized on this map?

4.3. Re: Text

4.3.1. There are places on the map where the information is very dense. Some examples of this are: Deer Park School to Lake Lagunitas and Phoenix Lake; and at various places on the flanks of Mt. Tam. In these areas the density of information on the map is increased by things like leader lines that are longer, text in all-caps closely alongside text that uses lower case, and in some instances, I had to use two different text sizes (one being small, the other being tiny) to label information in impacted areas.

Tell me about grasping the information on the map in these areas.

Is it difficult or easy to read?

Is it difficult or easy to tell things apart?

4.4. Re: Colors

4.4.1. Are you able to see colors on this map?

If you are colorblind, can you tell me about the colors you can and cannot see?

Can you point out features on the map that you have a hard time distinguishing because of color?

Do you have any guidance for me as I try to produce a map that is accessible in this way?

4.5. General Feedback, Critique, or Input

4.5.1. Do you like this map?

What do you like?

What don't you like?

4.5.2. Are there things that should go?

Are there things that are not included but should be?

4.5.3. Do you have any specific suggestions the final version of this map is produced?

4.5.4. You can write any additional thoughts or suggestions on the back page of the pamphlet under "Do you have any specific suggestions for this map?"

5. Closing (2 mins.)

5.1. Can you please fill out the bubbles on the front page of the pamphlet?

5.1.1. Usefulness

5.1.2. Efficiency

5.1.3. Effectiveness

5.1.4. Accessibility

5.2. Thank you. I really appreciate your help. It is very important to getting a map that is useful to you.

Appendix F

Design Criteria Interviews • Interview Script

1. What are the most important elements of the existing map? What works?
   - What themes do you refer to the most?
   - What elements make this a SAR map more than a typical visitor map?
   - Discuss symbols, colors, look and feel
   - Is the scale bar appropriately designed?
   - Are the scale units logical?
   - Are the symbols in the legend clear and do they visually transfer easily to the map?
   - Are the symbols, color rectangles, and associated text in the legend of sufficient size?
   - Are the symbols logically composed within the legend?
   - Does the legend logically relate to the map?
   - Is the representation of the graticule sufficient?

2. What is on the current map that has to go? What is on it that is not important?
   - Graphic distractions
   - Thematic distractions, extraneous information
   - Symbols, colors, look and feel

3. Are there elements that are missing from the map, that should be added?
   - Important SAR themes
   - Symbols, colors, look and feel

4. How would you evaluate the following map elements for this SAR map?
   - Readability, look and feel of symbols
   - Colors, look and feel
   - Figure-ground organization; thematic info clearly discerned from base map?
   - Visual hierarchy; within themes, among themes
   - Is the context on the map that is outside of MMWD sufficient?
   - Are you satisfied with the orientation of the map (N being 45° to the left)?

Appendix G

Design Criteria Interviews • Compiled Responses

Question 1: What on the map works?

Responses to the question "What themes do you refer to the most?"

- Drivability; 2WD, 4WD, ATV
- Wheelbase and overhead play into the determination
- Patrol Area 2, high search area
- Bermuda Triangle
- Trails
- Trail names
- Labels
- Picnic areas
- Parking
- Access, trail heads, points of entry
- Lakes
- Roads and trails
- Powerlines
- Communities
- Connections to SAR
- Points of entry

Respondents mentioned these map themes as "important" in the Design Criteria Interviews:

- Distances
- Trail sign locations
- Road marker locations
- Landmarks

- 3-dimensional topographic representation
- Visually separate symbology for different roads and trails
- Distances between points
- Trail names
- Trailheads
- Common visitor destinations
- Points of entry representation
- Grid, numbered w index
- Utility line locations
- Culverts

Question 2: What elements make the 2011 map a SAR map?

- The inclusion of non-system trails

Question 3: What on the map does not work?

Items on the 2011 map recognized as thematic distractions or extraneous information:

- Boat ramps

Items that should not be included in the map update:

- Fire hydrants
- Patrol areas
- Graticule

Map elements that should be improved in the map update:

- Contrast
- Figure to ground organization
- Differentiation between lines representing different types of trails
- Representation of connections between MMWD trails and adjacent
- Representation of MMWD patrol areas

    - Too much green
    - Boundary should be represented as a line, not a polygon with solid color
- Symbols
    - Ranger station
- Scale bar, scale should be written out in text
- Symbol appearance between legend and map

Question 4: What improvements to the map can be made?

- Water storage tanks, delineated by spring fed or pumped
- Reservoir symbol with spillway elevation, dam elevation, and lake depths
- UTM grid
- Latitude-longitude graticule
- Pump stations
- Points of interest, historical sites
- Contour lines that continue into adjacent lands
- Added to the legend:
    - Stable symbol
    - Lakes
    - Waterfalls
- Strong figure-ground organization
- More contrast

Map elements that would require further research for inclusion in a future update to this map:

- Mapping of:
    - Concentrations of past lost person incidents
    - Cellphone reception by wireless providers
    - Trail sign locations

  - Trail marker locations
  - Culverts under roads and trails
  - Distances between points on roads and trails
- Figure to ground organization
- Differentiation between lines representing different types of trails
- Representation of connections between MMWD trails and adjacent
- Symbols
- Ranger station
- Scale bar
- Symbol appearance between legend and map

Appendix H

Draft Map Assessment • Session Details

Assessment sessions:

- 12 March 2018, Participant: 01TH, San Rafael, 45 minutes
- 13 March 2018, Participant: 02NS, San Rafael, 60 minutes
- 14 March 2018, Participants: 03JMc, 04MC, 05PJ, 06DW, Fairfax, 90 minutes
- 14 March 2018, Participant: 07JI, San Rafael, 45 minutes
- 19 March 2018, Participant: 08MSJ, Fairfax, 90 minutes
- 19 March 2018, Participants: 09RS, 10SMc, 11RR, San Rafael, 45 minutes

Appendix I

Draft Map Assessment • Compilation of Respondent Background

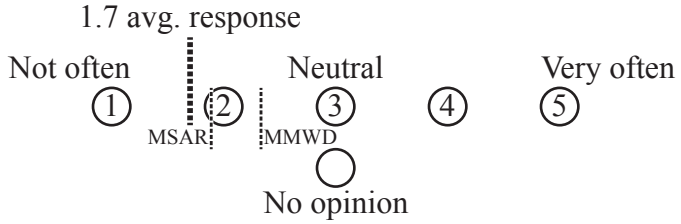
ID	• MMWD Ranger • MSAR Manager • Other (please specify)	What is your role in SAR?	Describe how you use maps in your work with SAR. Please give specific examples.	How many years have you been walking on the MMWD both personally and professionally?	Are you colorblind?
01TH	Professional Cartographer	Past cartographic consultant to MMWD for SAR cartography	--	10+	No
02NS	Retired GIS Analyst, Cartographer, MMWD	To assist in providing map and other geospatial info (GPS points and tracks) to searchers	Take existing GIS & new/ existing GPS data and produce in a format they can visualize	40+	No
03JMc	MMWD Ranger	MMWD SAR liaison	Establishing search areas; Establishing hasty search; Giving best access points to teams in field	35	No
04MC	MMWD Ranger	Hasty search; Overhead search; Agency rep (MMWD)	Used paper maps for plans; Use digital georeferenced maps for search in field (Avenza on mobile phone)	30+	No
05PJ	MMWD Ranger	SAR Manager	Passing on information; locations; spatial; landmarks; elevations	26	No
06DW	MMWD Ranger	Facilitator, SAR team	Whatever they (MSAR) provide	1.5	No
07JI	Retired Chief, Southern Marin Fire Protection District; Fire Response Consultant; Avid cartographer	Mapping	I have provided maps and mapping assistance to SAR, fire, and law enforcement	50+	No
08MSJ	MSAR manager; Mill Valley Fire Department	Team Leader	I have provided maps and mapping assistance to SAR, fire, and law enforcement	38	No
09RS	MSAR manager	Search Manager	Primary tool for search planning; distributed to teams for navigation; for briefings; updates for LE/government	10+	No
10SMc	MSAR manager	General Member, usually in overhead	Set up sartopo for site; create search areas; log radio calls for evidence/clues; import GPS tracks; modify layer to better show different aspects of area	9	No
11RR	MSAR manager	Search Manager	Planning and operations of searches, both before and during operations	15	No

Appendix J

Draft Map Assessment • Objective Section, Average Responses

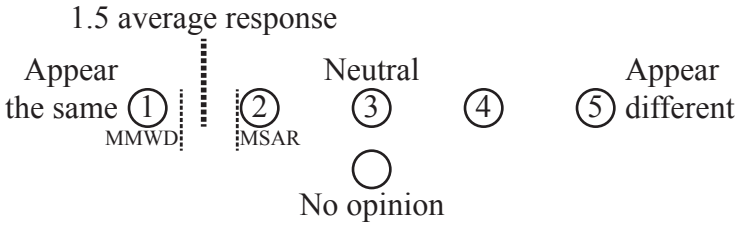
Following are the averages of the objective ratings of elements of the Draft Map as they are described above. The responses to the statements are on a scale from 1-5, the description of the ends of the scales are unique to each question. Averages are noted for overall responses, as well as for MMWD Rangers and MSAR Search Managers. Averages are based on 11 responses, unless otherwise noted.

1. After a brief introductory period of time familiarizing yourself with the map, rate how often you needed look away from the map to use the legend in order to understand the symbols on the map, from not often to too often.



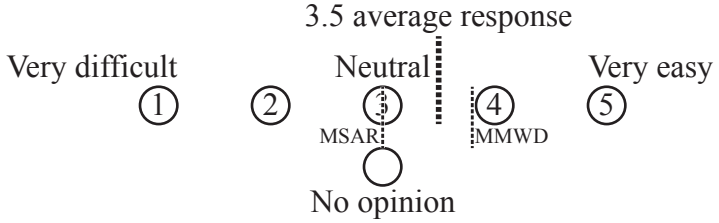
   - MMWD Ranger, 2.3 avg. response
   - MSAR Search Manager, 1.8 avg. response

2. Rate the appearance of the symbols in the legend compared to the appearance of those same symbols in the map portion of the sheet, from appear exactly the same to appear very different.



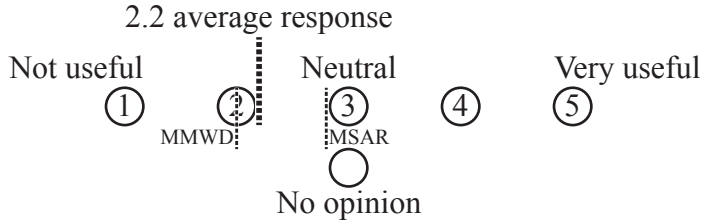
   - MMWD Ranger, 1.3 avg. response
   - MSAR Search Manager, 1.8 avg. response
   - Including 1 “No opinion”

3. Concerning the symbols composed of black and white graphics: Rate the ease of figuring out the meanings of the symbols, from very difficult to very easy.



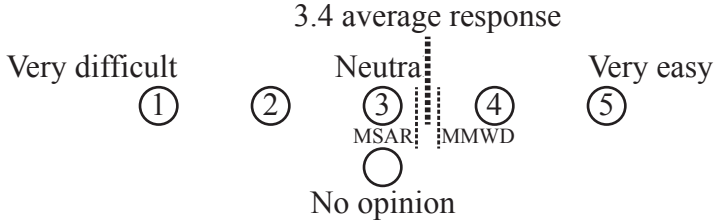
- MMWD Ranger, 3.8 avg. response
- MSAR Search Manager, 3.0 avg. response

4. Rate the usefulness of the graduated-in-size circles that symbolize the distribution and capacity of parking on MMWD; from not useful to very useful.



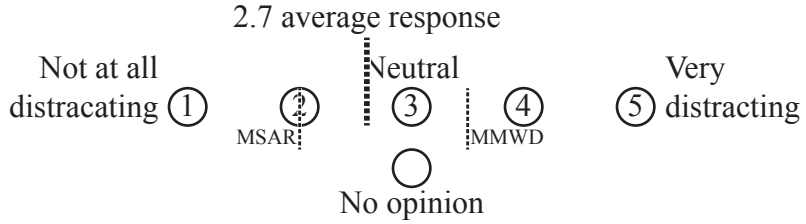
- MMWD Ranger, 2.0 avg. response
- MSAR Search Manager, 2.8 avg. response

5. Concerning the lines (various line widths and dash patterns) that represent roads and trails: rate the ease with which you were you able to distinguish between the five different types of roads and trails from very difficult to very easy.



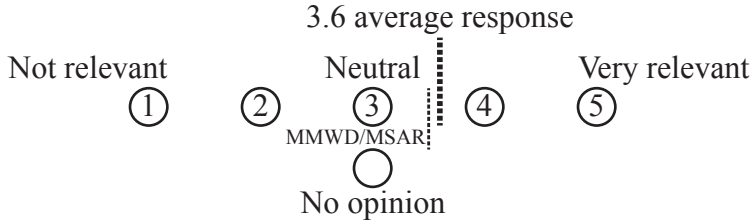
- MMWD Ranger, 3.5 avg. response
- MSAR Search Manager, 3.3 avg. response

6. Concerning the symbols composed of black and white graphics with associated leader lines and text: Rate distraction caused by those elements to underlying and adjacent graphics, from not at all distracting to very distracting.



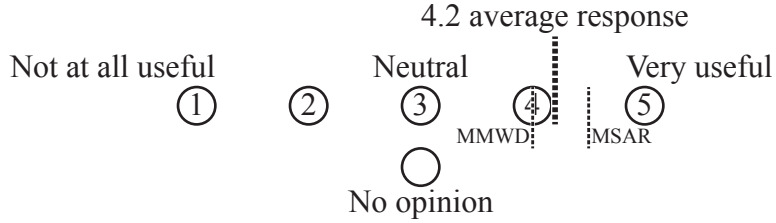
- MMWD Ranger, 3.5 avg. response
- MSAR Search Manager, 2.0 avg. response

7. Concerning the symbols on the map: rate the relevance of these symbols to your role in search and rescue from not relevant to very relevant.



- MMWD Ranger, 3.5 avg. response
- MSAR Search Manager, 3.5 avg. response
- Including 1 “No opinion”

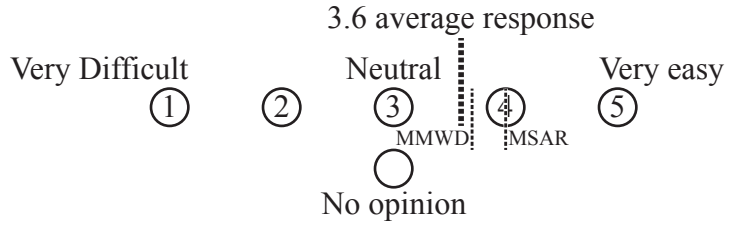
8. Rate the usefulness of detailing the map to show how roads and trails on MMWD connect to the roads and trails of adjacent jurisdictions and properties, from not at all useful to very useful.



- MMWD Ranger, 4.0 avg. response
- MSAR Search Manager, 4.5 avg. response

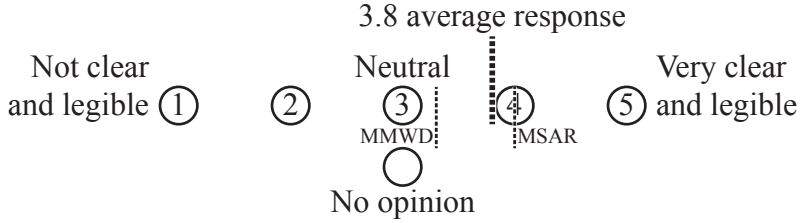
- Based on 10 responses

9. Concerning the text on the map portion of the sheet: rate the ease with which you were able to distinguish between text labeling roads and trails and text labeling points of interest and historical sites, from very difficult to very easy.



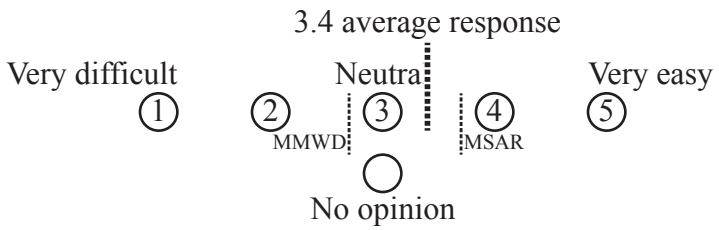
- MMWD Ranger, 3.7 avg. response
- MSAR Search Manager, 4.0 avg. response
- Based on 10 responses, including 1 "No opinion"

10. Concerning the labels on the map (text, symbols and associated leader lines): Rate the clarity and legibility of the information as it is affected by the density of information on the map portion of the sheet, from not clear and legible to very clear and legible.



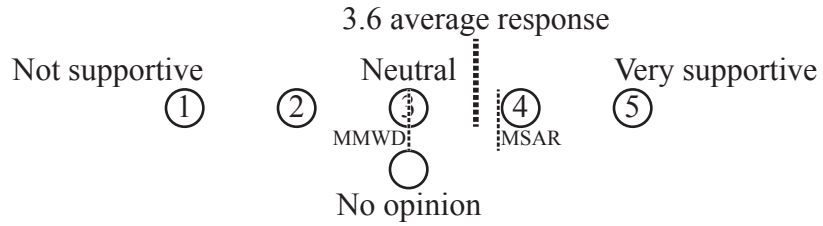
- MMWD Ranger, 3.3 avg. response
- MSAR Search Manager, 4.0 avg. response
- Based on 10 responses

11. Rate ease with which you were able to estimate distances on this map from very difficult to very easy.



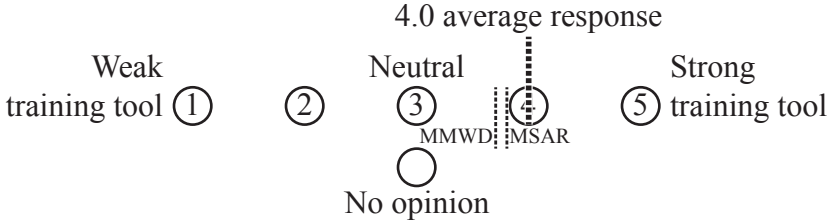
- MMWD Ranger, 2.7 avg. response
- MSAR Search Manager, 3.7 avg. response
- Based on 10 responses, including 2 “No opinion”

12. Concerning the design elements (i.e. lines, symbols, colors text, and types of information) as configured on this map: rate the support that you think the map will provide in your role in search and rescue, from not supportive to very supportive.



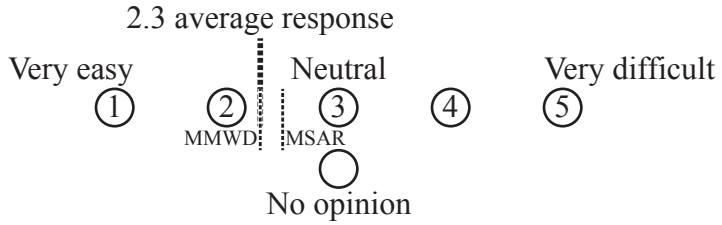
- MMWD Ranger, 3.0 avg. response
- MSAR Search Manager, 3.8 avg. response
- Based on 10 responses, including 1 “No opinion”

13. Concerning training a new person to perform your role in search and rescue: rate the strength of this map as a tool in such a training, from weak training tool to strong training tool.



- MMWD Ranger, 3.7 avg. response
- MSAR Search Manager, 3.8 avg. response
- Based on 10 responses

14. Concerning the colors (blue for streams and lakes, and brown for topography and parking symbols graduated-in-size) on the map: rate ease with which you were able to distinguish features bearing these colors, from very easy to very difficult.

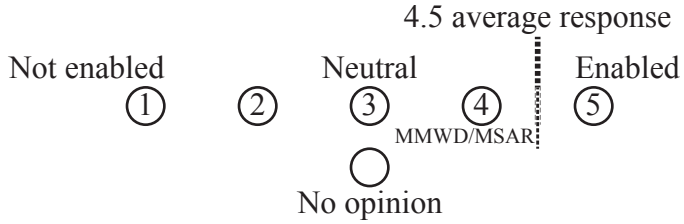


- MMWD Ranger, 2.3 avg. response
- MSAR Search Manager, 2.5 avg. response
- Based on 10 responses

Elements of Usability:

Usefulness

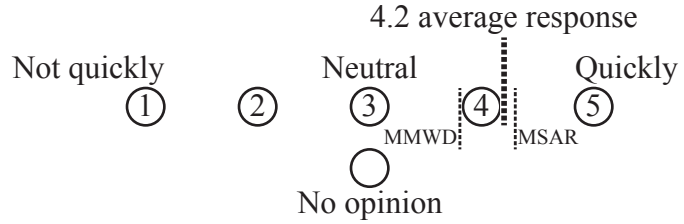
15. The user is enabled in performing intended tasks of map interpretation.



- MMWD Ranger, 4.5 avg. response
- MSAR Search Manager, 4.5 avg. response

Efficiency

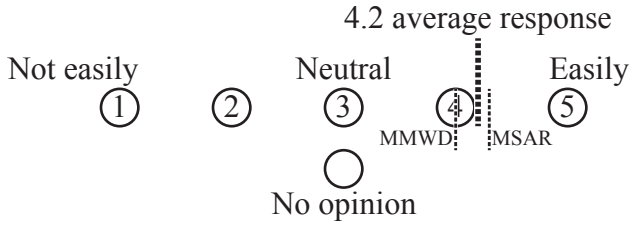
16. User can perform intended tasks of map interpretation with minimum effort.



- MMWD Ranger, 3.8 avg. response
- MSAR Search Manager, 4.3 avg. response

Effectiveness

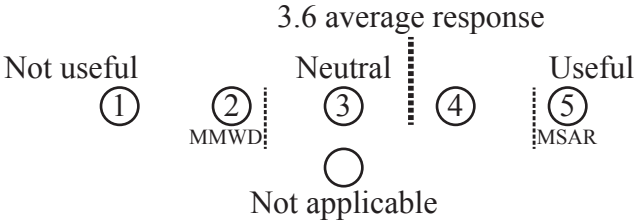
17. User can readily achieve outcomes for intended tasks of map interpretation.



- MMWD Ranger, 4.0 avg. response
- MSAR Search Manager, 4.3 avg. response

Accessibility

18. Map is useful if user is color blind.



- MMWD Ranger, 2.3 avg. response
- MSAR Search Manager, 4.7 avg. response
- Including 3 “Not applicable” responses
- Question is irrelevant as there are no colorblind respondents.

Appendix K

Draft Map Assessment • Interview, Compiled Responses

Following are the Interview questions and the responses, compiled and bulleted.

Interview (20 mins.)
How and when will you use this map?

- Operations
- In patrol vehicle every day
- On a phone in Avenza. Need to geo-reference the .pdf
- Need paper map
- Training, but it would need to be 11x17
- Planning
- At sartopo
- Searchers are given letter-size print-outs of the map from sartopo
- Could replace the Tom Harrison map that is currently used
- Needs tweaks
- Hasty search mode; use map w highlighter

Legend and Symbols
Tell me about the legend. How was the task of understanding the information in the legend and incorporating that information when you were looking at the map?

- Used the legend only quickly
- Symbols seem pretty standard, did not need to refer to them
- Pretty intuitive
- It is good to use picto-realistic symbols
- Measure of square distances in legend is unnecessary
- Didn’t really use the legend during the exercise
- Didn’t use the distance scale to solve the 50 yards issue in the exercise

- Utility lines, not on map
- Benchmark, not on map
- Don't include too much information; Victory Garden is obscure;
- The Fort and The Throne are important
- Must cabin sites be located? Some of them are very old locations evidence of the use is no longer present.
- Cerkel to cross out information that is extraneous
- Old Corral is significant
- Stone Fence is significant
- Don't label sites. Use UTM coordinates instead.
- Mine shaft is significant
- Didn't really look at the legend, because everything on the map is fairly intuitive.
- Somewhat useful
- Anything off-road should be in red
- Include ICP locations
- Fixed ICP locations; Sky Oaks RS, Throckmorton FS, Pantoll FS, Stinson Beach FS
- Mobile ICP locations; Natalie Coffin Greene Park, Rock Springs RS, East Peak Parking Lot; places where search can have restrooms and assemble groups of searchers quickly.
- Confused by differentiation of roads and trail line
- Use colors
- Primary trails (trails that are known to visitors) are too weak, should be more prominent
- Fire roads should be more prominent as well

How about the symbols themselves? Do they appear different or the same in the legend and on the map?

- They appear the same
- Appear the same
- Same (3x)
- Had to refer back and forth

How intuitive or not intuitive did you find the meaning of the symbols to be?

- They appeared the same
- Meanings were very intuitive
- Very intuitive
- Fairly intuitive
- Intuitive
- Dam symbol did not make sense
- Water tank symbol not clear
- Do not need pump or spring-fed water tank

Tell me what you think of the circles used to show the distribution and capacity of parking on the district.

- Fairly useless
- So, what?
- Nice cartography
- Don’t need them
- Rangers already know that information
- Circles are distracting
- Information is unnecessary
- Too much brown
- Lighten the symbols
- Remove the big symbols
- Too much information

- Too bold of a color, make it light gray
- Remove the symbols
- Rangers know the capacity of the parking on the District, don't need that information on the map
- Meadow club parking lot is not public. While it is there is not part of the District
- "P" symbols indicate a parking lot. Small symbols indicate parking on the side of the road.
- Did not care for them
- Somewhat useful
- Take them off, or make them uniform and tiny
- "P" symbols are fine
- Noting parking at turnouts or other places where there isn't a lot, is helpful

Will you use that information in your role?

- No
- No, all around
- Yes

Why or why not?

- Because I did production work in the office

There are five different line types (width and dash pattern) for five different kinds of roads and trails. Tell me about your experience in telling them apart.

- Did not distinguish well
- The use of color would better visually separate the trail symbols
- He advocates the use of red as a trail symbol, which is what he uses on his maps to great effect.
- Roads should be dashed
- Trails should be dotted

- This step is not easy. Keep at it.
- Needs to be better
- Hard to tell them apart
- Use color, specifically red
- Gray out the non-system trails
- Non-system trails can migrate over time
- Paved roads should be black
- Dirt roads should be brown
- Nomenclature for roads (MMWD); Road, primary > paved road open to the public; Road, secondary > unpaved road, restricted access, aka protection road; System trails, maintained; Non-system trails (knock symbol back to gray), not maintained; Abandoned trail > decommissioned trails, may not be passable
- Refer to nomenclature from 2005 Roads & Trails Plan
- Show paved, private roads. Different from public roads
- Show winter closures
- Difficult
- Had some difficulty telling them apart where it gets really busy in the High Marsh area.
- High marsh trail not represented well
- Abandoned trail symbol is good
- Five different types of lines work
- Incorporate red into trail type symbols
- St. John verifies that Matt Cerkel has the best awareness of non-system and abandoned trails
- Hard to differentiate
- Primary trails are too weak; can’t recognize non-system trails
- Add color, add red

- Should be able to see visually separated trails from a glance at the overall map. Eyes further away from the map, at a little distance. Shelton stood up and took a half-step back when he made the comment. He saw “some brown and some black’ with this glance.
- Use one color for the primary roads, another color for the fire roads, mute (use something less prominent) for the social trails. Social trails are still needed on the map, but they are secondary to MSAR Search Managers.
- It is complicated in the crowded part of the map

Some symbols are designed to stand out more than others. Can you point to two (or maybe more than two) different symbols that stand out well?

- Lakes
- Creeks
- Paved roads
- Picnic
- Parking
- Boat ramp
- Water
- All symbols stood out well
- Roads
- Parking
- Ranger stations
- Creeks; it would be nice to have seasonal and year-round designations on the creek line symbol.
- Contours stand out, could be backed off
- Geographic references
- Parking
- Picnic grounds
- Symbols in black squares

To take that idea a step further, can you point to two (or more) different kinds of symbols that do not stand out?

- Symbol for spring
- Bridge, lines not heavy enough
- Dirt roads
- Hiking trails
- Dam symbol, too much, symbol not necessary
- Fire station symbol, find a better symbol
- The fire engine from a road sign for fire house

- Trail names
- Fire roads to be red, solid

Are symbols that do not stand out still understandable, or not understandable?

- Yes
- Water tank symbol
- Do not use the “W” in BW square
- Do not include spring-fed or pumped designation
- Make it a cylinder
- All stand out pretty well

Why?

- It just takes a little more work

Are the symbols used on the map relevant to your role in SAR?

- Yes
- Remove Airplane Wreck symbol, keep cross-hatching for debris field as new symbol
- Hydrants; wharf hydrants around the watershed, not relevant to SAR.

- All water tanks have active hydrants
- There are pipelines w wharf hydrants, but the lines that hose hydrants are on are not always charged
- Probably are
- Dam symbols unnecessary
- Yes
- This map is not that different from a civilian wayfinding map, except this one has social trails on it.
- Has place names not previously seen

Is there information that should appear as symbols that is not currently symbolized on this map?

- No symbol for ranger house, maybe there should be
- No
- Include ICP locations
- Make trails in red, paved roads in black, everything in red gets searched by MSAR
- Include symbols for groundcover; brush (green dots), grass (white), marsh, granite (white), tree canopy (open or closed) (green)

Text

There are places on the map where the information is very dense. Some examples of this are: Deer Park School to Lake Lagunitas and Phoenix Lake; and at various places on the flanks of Mt. Tam. In these areas the density of information on the map is increased by things like leader lines that are longer, text in all-caps closely alongside text that uses lower case, and in some instances, I had to use two different text sizes (one being small, the other being tiny) to label information in impacted areas. Tell me about grasping the information on the map in these areas.

- It is what it is. The area is crowded. You do the best you can.
- No opinion; It is what it is; Respondent has experienced these decisions
- Fix the label for “Mount Tamalpais” on N flank of the mountain; make it read better.

- If there were more colors it would be easier to distinguish
- Might want to reduce text size on trail labels
- Leader lines are effective, they keep dense areas open
- Could use the text to make information more informative. Scale back secondary information
- Missing a lot of trail names
- 6pt. font is effective, Bald Hill elev. Cited as an example

Is it difficult or easy to read?

- Challenging
- Maybe use masking
- Leader lines are too thin

Colors

Are you able to see colors on this map?

- Yes
- Yes
- No problem
- Yes

If you are colorblind, can you tell me about the colors you can and cannot see? Can you point out features on the map that you have a hard time distinguishing because of color?

- Water
- Symbol for spring

Do you have any guidance for me as I try to produce a map that is accessible in this way?

- Use colors
- Don’t worry about the color-blind population
- The trails should be a very different color than the background
- Use contrasting colors

- Primary roads, fire roads should be color-coded
- Include variations of labels as a tool to differentiate trails
- Leave text in black

General Feedback, Critique, or Input
Do you like this map?

- Yes (6x)

What do you like?

- Size
- Orientation
- Colors
- Fade at the edge of mapped area
- Page arrangement
- There is a lot of information on the page
- Orientation is good
- Size is good, can see the entire property
- "I like all maps. I'm a map guy"
- Scale
- Like the big size
- Big map of the watershed that is easy to read
- Like the new information, place names, etc.; social trails, airplane wrecks, things that are attractive nuisances
- Leader lines helping to clear out busy areas
- Text is clean
- POI, historical sites, abandoned, and non-system trails bring interest to the map

What don't you like?

- It gives "a good idea" of the landscape

- Can see the main roads well
- Lack of connection to adjacent jurisdictions
- Hard to distinguish the trails and the trails and the contour lines
- Fire roads don't stand out from regular trails
- Not much contextual information off the watershed
- N is not quite vertical
- Maps printed out of sartopo are going to be north-vertical
- No latitude-longitude on map

Are there things that should go?

- Parking graduated symbols, get rid of or make smaller
- Pine Mountain Tunnel
- Administrative Boundary; remove the dashed line, leave the wide transparent line
- Dam symbol
- Don't need spring-fed v. pumped in water tank symbol
- Airplane wreck symbol
- Symbols are too numerous
- Square area scale
- Legend is too big, too much information
- The parking information
- Brown parking symbols
- Largest parking symbols
- Square distance scale
- Historical data, or new place names that have not previously appeared on maps could go on a different layer or be in a different color. This could make room for very dense information layers like culverts and road markers.

Are there things that are not included but should be?

- Include symbol for ranger residences
- Canyon Trail not labeled
- No symbol at Peters Dam
- Water tank on Shafter Grade, Cerkel has located on his map mark-up
- Label for Oak Tree Junction, near Six Points. On McConneloug's map mark-up.
- Pipeline bridge over trail, 40-50 ft. off the ground from Eldridge Grade to Windy Ridge/Indian Fire Road.
- Gates
- Locked gates
- Lat-long grid
- UTM grid

Do you have any specific suggestions the final version of this map is produced?

- Check contour interval/lines
- Check lake level information
- Add more trail names; Canyon Tr., Van Wyke Cr.
- Name all streams clearly, they are one of the first features that many will use to orient themselves to the map
- UTM grid may be helpful
- For purposes of printing look at PMS colors blue 299 and brown 471. Offset printers will not handle CMYK as well as they will handle a Pantone color. These solid proprietary colors are put down in an offset printer with one run over the location of the line, in this solid color or percentage of. CMYK has to go over the same line up to four times to make the color. That repeated attempt at the same line can lead to ghosting, or not perfectly registered details in places like contour lines.
- Move legend to the top of the map
- Make this map location searchable

- There are additional airplane wreck sites outside of the District; White Hill, Bald Hill (2 large divots into grade visible on aerial photography)
- Added a symbol on map for missing water tank near Phoenix lake
- Add power lines
- Add contact information for adjacent jurisdictions
- Connect the map to adjacent communities/jurisdictions
- Make it a map all the way to the edge, don't fade the map information
- Water tanks
- Water sources, like fire hydrants
- See map mark-up for alignment of pipeline from Kent Lake to Bon Tempe WTP and Baltimore Canyon.
- Contrast underlying map v. trails
- Trails in a different color or use bolder lines
- Not enough separation between trails and between trails and base
- Eyes wander from trails in to contours
- Drop topo and hillshade. Not necessary at sartopo
- Use classifications; primary roads, trails, fire roads
- Include trail signs @intersections
- Include (locking) gate information
- Include latitude-longitude grid on map
- Meadow Club parking lot has never been used by MSAR

You can write any additional thoughts or suggestions on the back page of the pamphlet under "Do you have any specific suggestions for this map?"

- Phoenix Lake 174' elev. WRONG
- Topo lines too prominent, make them less bold
- Trails at the edges of lakes are not accurate. The trails do not go into the water. Trails at the water's edge need to be verified in the field.

- Include notations for winter road closures
- There are many more springs than are indicated on the map. Cerkel to locate noticeable landmarks in his .kmz file.
- We went through a detailed editing of the nomenclature for the roads and trails in the legend. Editing is on Wick's map in green pen.
- Use more colors
- Label adjacent jurisdictions
- Make larger scale inset maps. Put them on the back. North area, south area
- Do not make this map suitable to color blind individuals
- McConneloug has an Eagle Scout who would volunteer to help w verification of the map
- Contours are labeled in meters. Need to be feet
- Make the water district property in green
- Connection to context; label with words and arrows
- Make fire roads solid color
- Get surrounding jurisdictions called out
- Make clear connections to adjacent jurisdictions
- Lost Person Behavior App; does travel distance calculations from PLS based on factors of lost person behavior
- Initial planning point place last seen (PLS) place last known (PLK)
- Introduced the term "black holes." Places on the watershed where they routinely get lost people. Poor cell connectivity, north-facing slopes that get dark first, large areas away from main roads, can have poor signage, Kent Lake is an example where signage helped defray lost person cases. In these places the search instructions are the same. MSAR has repetitions with the process of getting teams into the field in these places.
- We reviewed a case of a black hole search that evolved down to a tight grid search in a thickly wooded area. Fascinating.

- Very informative; I really got a deep look at what he is thinking about. While the session was going on, he was responding to texts as part of an effort to get a search team up to Bear Valley in full winter conditions to participate in a search for a missing skier.
- He walked me through a deck of a case study from 2014 (begins at 1:01:48 on audio, approximately 15 minutes in length) of a woman who went missing on the mountain. A late clue in the case was cellphone data. The MP's phone last made contact with a cellphone tower in El Cerrito, but her whereabouts were confirmed on Mt. Tam. MSAR had a GIS analysis done to see which slopes on the mountain had the aspect necessary for her cellphone to interact w the tower in El Cerrito. That result was further overlaid with areas that had high enough canopy to hike under. The resulting intersecting area of these two analyses became the focus of the search. Which was search on a tight grid and the MP was found, deceased.
- Better said: MP's phone hit El Cerrito cell phone tower. What aspects of Mt. Tam are going to be able to hit that cell phone tower? Within those zones, where would a person be able to navigate on/off-trail without too much trouble? Redwood forest that skirt Corte Madera Ridge, Blithedale Ridge, and some areas above the Hoo Koo e Koo Trail. Search was refocused to these areas, the areas were grid searched, and victim was found.
- Interesting story of the technological bump given to this case, cellphone data, and GIS analysis
- Check Olmstead maps
- All Risk Response map; Fire, law enforcement, EMS, SAR; risk response is the process of developing strategic options, and determining actions, to enhance opportunities and reduce threats to the project's objectives. A project team member is assigned to take responsibility for each risk response.
- Missing a lot of trail names
- SAR searchers do not generally recognize boundaries between jurisdictions. Most searches go beyond the watershed.

- Regular searches, within MSAR, for the first operational period or two, first 12 hours.
- Mutual aid search goes through the state calling in assistance from surrounding jurisdictions.
- Unified command w MMWD, MSAR. Both are stakeholders
- At sartopo.com; Harrison layer used to be the standard for MSAR. MapBuilder has become more commonly used. Instructions can be messaged or emails.
- Sartopo demo: government layer (Marin Community) has structures on it.
- A map intended for sartopo use does not need to have hillshade or topo lines on it
- Perhaps one map for printing and another map bound for sartopo?
- MW… get Avenza rolling on your phone!
- Cellphone, internet connectivity on MMWD is “fairly poor”

These are accounts taken from audio recordings of the Draft Map Assessment Interviews. They are very close to exactly what was said. Chapter 6 synthesizes this feedback, and identifies changes to the map that will result, appearing in the Updated Map.