Stakeholder Elicitation for Long Island Sound Dredged Material Management Plan

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Executive Summary

In order to identify stakeholder values on evaluation factors for potential dredged material management alternatives as part of the Long Island Sound Dredged Material Management Plan (DMMP), the US Army Corps of Engineers (USACE), New England District partnered with members of the Engineer Research and Development Center (ERDC) Risk and Decision Science Team to organize a stakeholder engagement exercise. During a series of meetings with the DMMP Working Group, the stakeholders were tasked with collaboratively building a decision model. The resulting model included several general alternatives, criteria, subcriteria, and metrics relevant to stakeholder interests in the Long Island Sound region. Individual interviews were also conducted to elicit judgments regarding the importance of the developed criteria such as environmental media, ecological receptors, economics, and human welfare in relation to the alternatives.

Through interviews and surveys, each representative of a stakeholder organization was able to contribute their view of the relative value/utility of different environmental impacts, health risks, social benefits, economic costs, and other high-level criteria in the context of dredged materials placement. The elicitation process was conducted to fairly and transparently integrate divergent stakeholder views in a way that lets all participants voice their preferences and concerns without one voice or viewpoint dominating the discussion.

Results show that, in general, stakeholders tended to agree that all criteria were at least somewhat important, with the exception of a few notable outliers that weighted the Economics criterion extremely heavily. However, on average there was a strong relative agreement among the diverse stakeholder group.

Results will be incorporated in the New England District's updated Dredged Material Management Plan to guide long-term sediment management in Long Island Sound.

Multi-Criteria Decision Analysis, in particular, is a robust means by which rational and transparent resource allocation decisions can be made while considering stakeholder views. The use of formal decision analytical tools can efficiently augment the prioritization of dredged material placement sites in such a way that is transparent, scalable, analytically rigorous, and defensible.

Background

Ensuring safe and reliable navigation channels and associated infrastructure throughout the waters of the United States is one of the missions of the US Army Corps of Engineers. In the northeast, Long Island Sound (LIS) represents an important body of water for shipping, recreation, and the environment. Over the next 30 years, it is anticipated that the dredging centers located in the LIS region will require dredging of approximately 38.5 million cubic yards of material. New Haven, Bridgeport, New London, Connecticut River, Clinton/Westbrook, and Norwalk dredging centers account for the bulk of the dredging needs in the future (Figure 1).
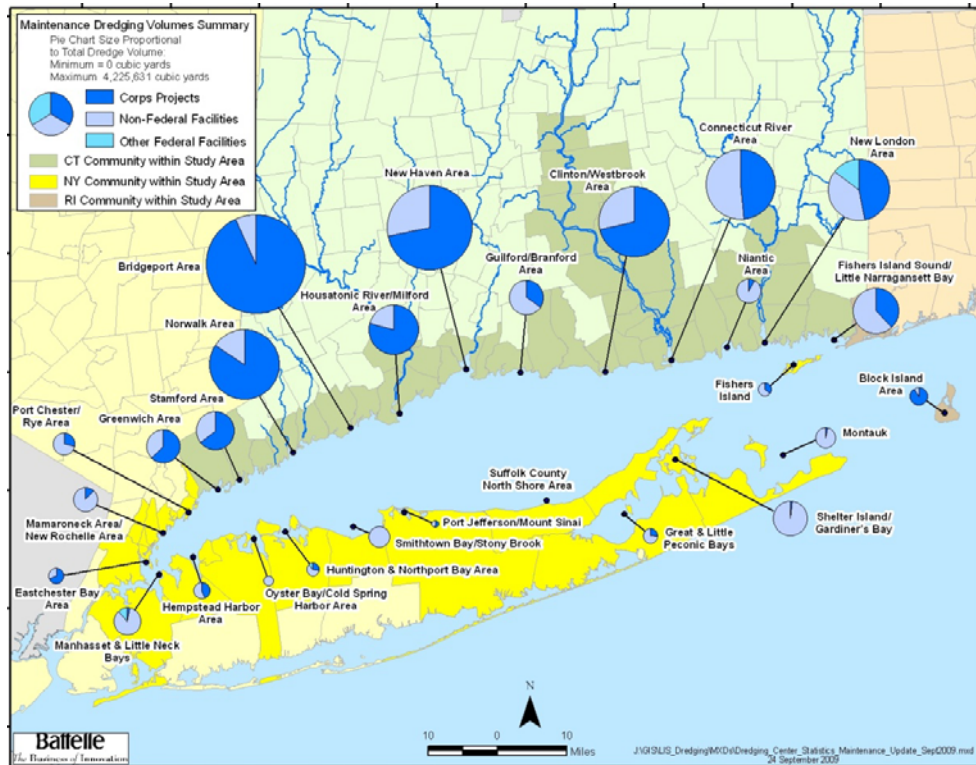
Figure 1: Dredging Needs in Long Island Sound Study Area

The development of a Dredged Material Management Plan (DMMP) for LIS was requested by the Governors of Connecticut and New York after the Environmental Protection Agency (EPA) designated two open water dredged material disposal sites in LIS. The overall goal of the LIS DMMP is to develop a comprehensive dredged material management plan for the Corps of Engineers that recommends practicable, implementable solutions to manage dredged material from Federal Navigation Projects in an economically sound and environmentally acceptable manner. The LIS DMMP will include an in-depth analysis of all potential dredged material management alternatives including open-water placement, beneficial use, upland placement, and innovative treatment technologies, which can also be used by dredging proponents in developing alternatives analyses for their dredging in the LIS vicinity.

The process calls for Federal agencies to seek public input regarding development of the LIS DMMP.   However, sediment management and remediation projects are often performed in complicated political environments where stakeholders are sensitive to different decision paths and actively engaged in championing for or against specific project alternatives. Inviting the participation of relevant stakeholder groups at the forefront of the decision process can avoid later conflict, but only if all parties feel that their views are being accurately and meaningfully incorporated in the process and if all groups feel they have a fair say in the final recommendation.

To this end, the ERDC partnered with USACE New England District to conduct a stakeholder engagement exercise. A working-group of representatives from various stakeholder organizations was formed and consulted to help identify priorities that would be used in screening potential sediment management alternatives for each dredging center in the region's updated Dredged Material Management Plan. The working group collaboratively built a decision model that framed the problem of dredged material placement in terms of dredged material type, potential alternatives, criteria, sub-criteria, and metrics relevant to the LIS stakeholders. An elicitation of preferences, represented as criteria weights, was then conducted. By soliciting stakeholder preferences, the process sought to increase stakeholder involvement at the front-end of the prioritization and lead to improved stakeholder buy-in in the results.

Collectively, average decision weights were to be derived for a Multi-Criteria Decision Analysis (MCDA) of sediment placement sites according to the type of dredged material (e.g., unsuitable, coarse, fine). Separately, District and local experts will provide numerical data for the performance of each placement site on each weighted criterion to prioritize locations.

Methods

The stakeholder engagement process centered around the formation of a working group, comprised of individuals representing Federal and State agencies as well as stakeholder organizations from both New York and Connecticut. Grounded in well-established best practices for stakeholder engagement, the following steps were performed:

Step 1: Establish a common understanding. Together, we explored background materials on various dredged-material placement alternatives so that all WG members could reach a common basis of understanding. Topics included the objectives behind the DMMP, an overview of sediment quality testing, and the definition of various placement alternatives and dredged material types (i.e., suitable fine, suitable sandy, and unsuitable).
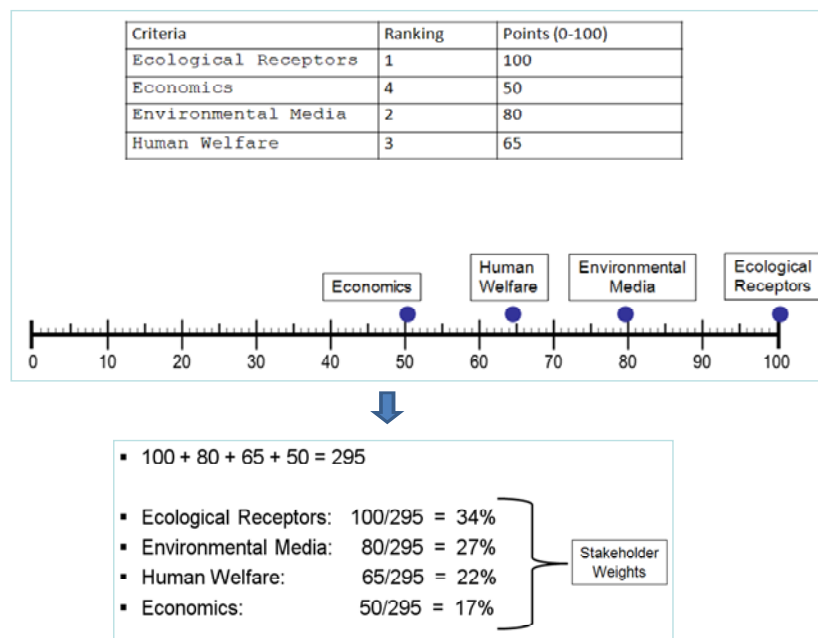
Step 2: Develop a collaborative decision model. As a group, we developed a broad hierarchy of criteria, sub criteria, and metrics for evaluating the impacts and benefits of dredged material placement. Based on insights from the field of Decision Analysis, the components of the decision problem were identified and organized by the members of the WG. Starting at the highest level, broad criteria were identified, followed by specific sub-criteria, and then metrics with which to assess the sub-criteria. This was conducted

in a series of WG meetings, then refined individually through worksheets, and finalized again at a WG meeting.

Step 3: Conduct Individual Interviews. Once a comprehensive decision model was built, the stakeholders were asked to provide their preferences towards the importance of the identified criteria and sub-criteria. In individual interviews, WG members shared the perspectives of their respective organizations by quantifying preferences for and trade-offs between these impacts and benefits of dredged-material placement. This was done in the context of establishing the relative importance of each of the criteria and sub-criteria already identified in the evaluation framework. Prior to conducting the interviews, a read-ahead packet was distributed to summarize the progress of the WG and instructions on preparation for the interviews.

Interviews were conducted by telephone. During the interviews, interviewers were asked to rank the criteria (or subcriteria) from 1 to n, where n is the number of criteria or sub-criteria. Item #1 was given a relative 100 points. We then asked "If item #1 was given 100 points, how many points would you give to item #2 relative to item #1?" This was repeated for all criteria or sub-criteria. In addition, the stakeholders were given the opportunity to add supplemental narrative responses along with their point allocations.

Step 4: Synthesize the Data. The interview responses were then coalesced and summarized to show the distribution of priorities outlined by the Working Group members that were interviewed. Points allocated to criteria and sub-criteria were converted into weights based on the method shown in Figure 2.

Criteria	Ranking	Points (0-100)
Ecological Receptors	1	100
Economics	4	50
Environmental Media	2	80
Human Welfare	3	65

- 100 + 80 + 65 + 50 = 295

- Ecological Receptors: 100/295 = 34%
- Environmental Media: 80/295 = 27%
- Human Welfare: 65/295 = 22%
- Economics: 50/295 = 17%

Stakeholder Weights

Figure 2: Weight Derivation

The responses were grouped and categorized in a number of ways, including by state, organizational mission, and organizational sector. These initial results were reviewed with the WG.

Results

The structure of the decision model developed by the WG is shown below in Figure 3. The specific breakdown between criteria, sub-criteria, and metrics can be found in Appendix 6.
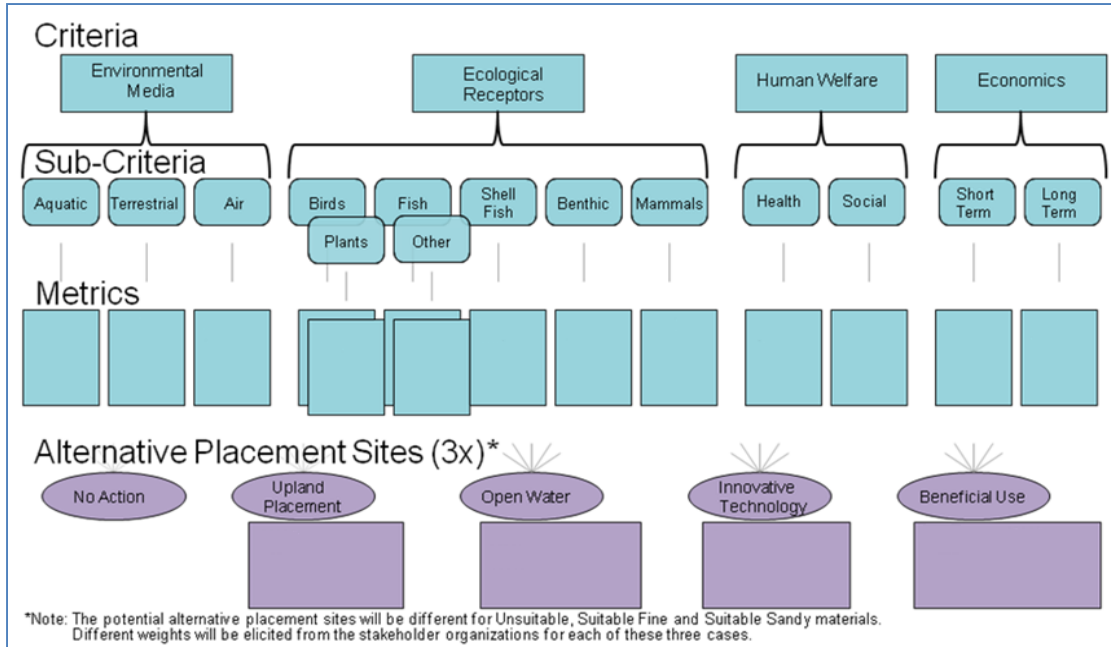
Figure 3: LIS Decision Model

An essential part of stakeholder engagement is to ensure that everyone is speaking a common language – therefore part of the exercise involved reaching shared definitions of the alternatives, criteria and sub-criteria, and dredged material types (Tables 1,2,3).

Table 1: Classification of Placement Alternatives by Material Type

Alternatives	Type of Material		
Type of Alternative	**Unsuitable**	**Suitable Fine**	**Suitable Coarse (e.g., Sandy)**
No Action:	No Action	No Action	No Action
Upland Placement:	Shoreline CDF*, Upland CDF*, Mines & Quarries*, Landfills*	Shoreline CDF*, Upland CDF*, Mines & Quarries*, Landfills*	Shoreline CDF*, Upland CDF*, Mines & Quarries*, Landfills*
Aquatic Placement:	In-Harbor CAD Cell, Confined Open Water Placement, Island CDF	Unconfined Open Water Placement, Island CDF	Unconfined Open Water Placement, Island CDF
Innovative Treatment Technologies:	Varies by Product* (results in material unrestricted for final placement or use)	N/A	N/A
Beneficial Uses:	Brownfields & Other Redevelopment*, Island Creation or Restoration	Brownfields & Other Redevelopment*, Island Creation or Restoration, Agriculture*/ Aquaculture†, Shoreline Restoration†, Habitat Restoration / Enhancement or Creation, Road Bed & Berm Material*, Landfill* & CDF* / CAD Cap Material	Brownfields & Other Redevelopment*, Island Creation or Restoration, Agriculture*/ Aquaculture†, Shoreline Restoration†, Habitat Restoration / Enhancement or Creation, Road Bed & Berm Material*, Landfill* or CDF* / CAD Cap Material, Beach and Dune Nourishment†, Nearshore Bar Placement, Asphalt / Cement & Other Aggregates*

*Requires use of a dredged material transfer facility
†May need the use of a dredged material transfer facility
 CDF = Confined Disposal Facility; CAD = Confined Aquatic Disposal

Table 2: Criteria and Sub-criteria Definitions

Environmental Media	**"Media sustaining organisms or human activities"**
Aquatic	"The water areas at or around dredged material placement sites, including the ocean & large bodies of water directly affected by material placement"
Terrestrial	"The land areas at or around dredged material placement sites, including soil and the land surface, wetlands, grasslands, agriculture, and brownfields, etc, and including adjacent surface and groundwater"
Air	"The air at or around dredged material placement sites"
Ecological Receptors	**"Specific biological organisms affected by dredged material placement"**
Birds	"All avian species, including shorebirds, waterfowl, land-based birds, etc."
Fish	"Finfish"
Shellfish	"Shellfish, including clams, lobsters, crabs, oysters, etc."
Benthic	"Bottom dwelling invertebrates, worms, etc."
Mammals	"All mammalian species, land-based and marine"
Plants	"Aquatic and non-aquatic plants, including algae"
Other	"Other species of concern, as appropriate"
Human Welfare	**"Non-monetized human values"**
Health	"Human health effects resulting from exposure to dredged materials"
Social	"Social benefits and impacts arising from dredged material placement"
Economics	**"Monetized costs and benefits"**
Short Term	"Monetary effects occurring within 1 year of project commencement"
Long Term	"Monetary effects occurring 1 or more years after project commencement"

Table 3: Dredged Material Types

	Unsuitable fine material, with a significant silt and or clay component, that has tested as chemically and biologically unsuitable for unconfined aquatic placement and requires some means of containment, whether in-water (CAD Cells) or upland, or require treatment before final use or placement.
	Clean fine material with a significant silt and or clay component, relatively free of contaminants or from pre-industrial or glacial deposits, suitable for aquatic or upland placement or beneficial uses such as habitat creation.
	Clean sandy material suitable for beach or nearshore bar nourishment, aquatic placement, or a wide range of in-water or upland beneficial uses.

For the individual interviews, 20 participants responded, each representing their respective organization. Table 4 gives an overview of the participants, classified by geographic location, mission, and organizational sector.

Table 4: Participation Summary

Number of Respondents:	20	
By Area Represented	**Number**	**Percentage**
CT	15	75.0%
NY	2	10.0%
Other (e.g., Federal)	3	15.0%
By Primary Mission	**Number**	**Percentage**
Environmental	5	25.0%
Commerce	8	40.0%
Mixed	7	35.0%
By Organization Sector	**Number**	**Percentage**
Fed/State	7	35.0%
Local/Regional	6	30.0%
NGO	7	35.0%

Figure 4 and 5 show the broad results from the individual interviewing. Table 5 shows the summary statistics. In general, we see that among the high level criteria, Economics scores highest among the stakeholders. However no criterion ever scores below 20% importance.
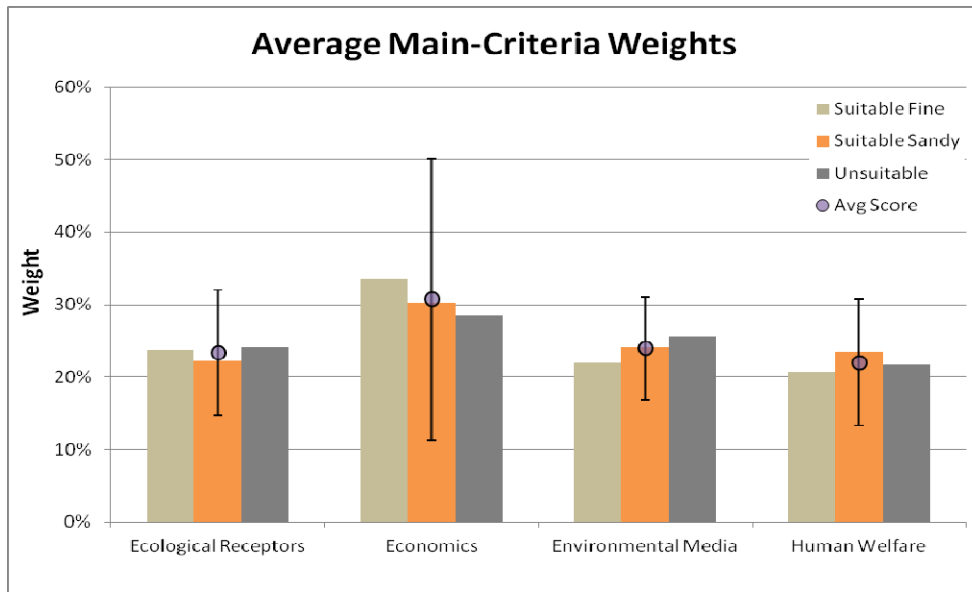
Figure 4: Average Main Criteria Weights
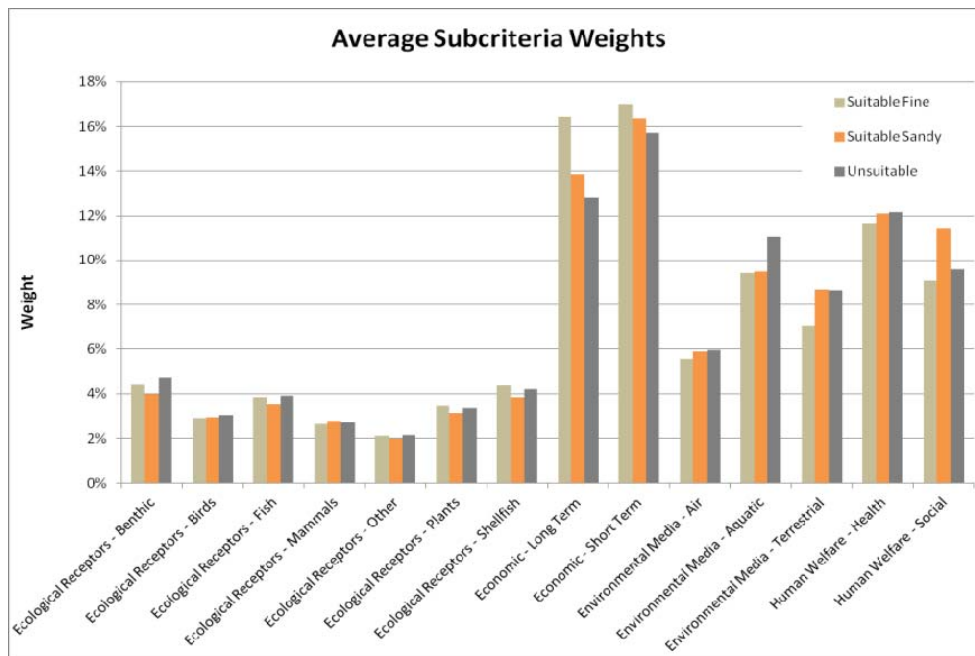
Figure 5: Average Sub-criteria Weights

Table 6: Results Summary - Weights Averaged Across All Material Types

Main Criteria	Average	Median	Std. Dev.	Range
Ecological Receptors	23.3%	24.6%	8.7%	37.1%
Economics	30.7%	25.3%	19.4%	82.6%
Environmental Media	23.9%	25.3%	7.1%	31.2%
Human Welfare	22.0%	24.1%	8.7%	43.5%
Sub-criteria				
Ecological Receptors - Benthic	4.4%	4.1%	1.9%	7.3%
Ecological Receptors - Birds	2.9%	3.3%	1.5%	6.7%
Ecological Receptors - Fish	3.8%	3.9%	1.7%	6.8%
Ecological Receptors - Mammals	2.7%	3.0%	1.3%	4.4%
Ecological Receptors - Other	2.1%	2.0%	1.9%	7.2%
Ecological Receptors - Plants	3.3%	3.6%	1.7%	10.3%
Ecological Receptors - Shellfish	4.1%	3.7%	1.8%	8.6%
Economic - Long Term	14.4%	12.3%	9.1%	51.3%
Economic - Short Term	16.4%	12.5%	12.5%	58.9%
Environmental Media - Air	5.8%	6.2%	2.4%	10.6%
Environmental Media - Aquatic	10.0%	9.1%	4.2%	21.8%
Environmental Media - Terrestrial	8.1%	8.3%	3.1%	12.7%
Human Welfare - Health	12.0%	12.5%	4.6%	26.4%
Human Welfare - Social	10.0%	11.2%	4.9%	20.8%

Discussion and Lessons Learned

Average results from the interviews show that Economics was the preferred criterion, with Environmental Media, Ecological Receptors, and Human Welfare all scoring approximately equally (just above 20%). This is partially due to a small number of respondents who assigned all or nearly all of their weight to that criterion at the expense of the others. This skewed the average weight for Economics upwards (hence the large standard deviation). However, given the spread in responses (see Figure 6), it may not always be the case that Economics is preferred, in fact there were many cases when it was ranked lowest.

However, regardless of the few outliers, it is important to note that all of the four main criteria ended up being weighted very closely to one another, despite the variety of stakeholder groups surveyed. This seems to show that most stakeholders understood and accepted that no criterion was singularly important and that coupled social-environmental systems are complex and interdependent, and therefore many criteria are necessary for the wellbeing of the LIS area as a whole. This is reflected in the way that the stakeholders agreed to categorize the criteria – roughly approximating the "triple bottom line" of sustainability (environment, society, economics).

Lessons Learned

- It is beneficial to focus the discussion on values and criteria rather than specific alternatives.
- Professional facilitation at working group meetings is beneficial for running smooth meetings and resolving conflicts.
- Despite stated interest, ensuring participation and responses from stakeholders can be difficult.
- Ensure frequent and open communication and a variety of knowledge input.
- Be clear about how decisions will be made and the type of influence stakeholders can have on the decision.
- Decision-analytic tools can help streamline sediment-management decisions, add rigor to the decision process and transparently incorporate divergent stakeholder views.

Recommended Next Steps

While the results of the study give us important insights into the preferences of the LIS stakeholders, there are additional tasks that can leverage this work towards the ultimate goal of the DMMP - to be able to prioritize, and therefore recommend, dredged material placement options at a number of sites. Proper execution of both of the recommendations below is contingent, in part, upon the data used within these analytical tasks. Thus, data collection efforts will be necessary. However, the New England District should have most of the necessary data available.

Recommendation 1: Conduct a formal decision analysis using MCDA. By combining the evaluation hierarchy and relative priorities expressed by the Working Group with a suite of technical site, use and technology analyses conducted by the Corps of Engineers, a summary evaluation and ranking of the placement alternatives for each LIS dredging center can be identified. The formal prioritization of placement alternatives requires the integration of the stakeholder preferences that were elicited and the site assessment data that was researched.

There are several important benefits that the MCDA process brings to dredging prioritization that may not be readily available through traditional approaches. An MCDA approach is transparent – interested parties can access and understand all assumptions leading to the final prioritization. This is especially important for continued understanding of the DMMP over the coming decades. Also, the MCDA process is flexible, and can be easily extended to prioritize specific dredging and placement sites or to update future results with new locations and technologies not currently available. Because organizational values are relatively stable, the weightings can continue to be applied as the data in the region develops over time. Lastly, the MCDA approach is fair to all involved. Each organization is allowed to influence the site prioritization through individual interviews; this can be achieved without intervention from other participants.

Overall, these benefits are anticipated to improve the utility of the DMMP and its public and political acceptance in the Long Island Sound region. Soliciting this public

involvement is anticipated to improve the ultimate public acceptability of DMMP recommendations.

Recommendation 2: Life Cycle Assessment. Managing dredged sediments in a way that properly balances environmental risks and benefits is often a point of controversy between stakeholders. Current decision making includes environmental criteria, but is often limited to factors measuring local or immediate effects. Consequently, public opinion often favors placing even suitable dredged materials in distant landfills. The environmental impacts associated with the additional moving and handling activities of this preference, however, are also relevant for decision making and may even outweigh impacts originating from the dredged material quality itself. Specifically, the variety of distributed and long-term impacts resulting from transportation by truck or barge, use of loading equipment, and long-term site management have implications for management criteria like carbon emissions, environmental and occupational health, and social welfare. Long-term and distributed environmental benefits from beneficial uses of dredged sediments can be similarly included. Life Cycle Assessment (LCA) is a method of accounting for a wider range of impacts and benefits than are included in existing risk assessments strategies. For example, the use of LCA in the related field of soil remediation has shown that risks originating from remediation processes often exceed the environmental risks from the prior contamination.

Appendix 1: Participation Summary

Table A1-1: Classifications of Interview Participants

Respondent	State			Primary Mission			Organization Sector		
	CT	NY	Other	Environmental	Commerce	Mixed	Fed/State	Local/Reg	NGO
1	x				x				x
2		x				x	x		
3	x				x			x	
4	x				x			x	
5			x			x	x		
6	x					x		x	
7			x	x					x
8	x					x		x	
9	x					x	x		
10	x				x		x		
11	x				x				x
12	x				x				x
13	x				x			x	
14		x		x			x		
15	x				x			x	
16	x					x	x		
17	x			x					x
18	x			x					x
19			x			x	x		
20	x			x					x
Total	15	2	3	5	8	7	7	6	7
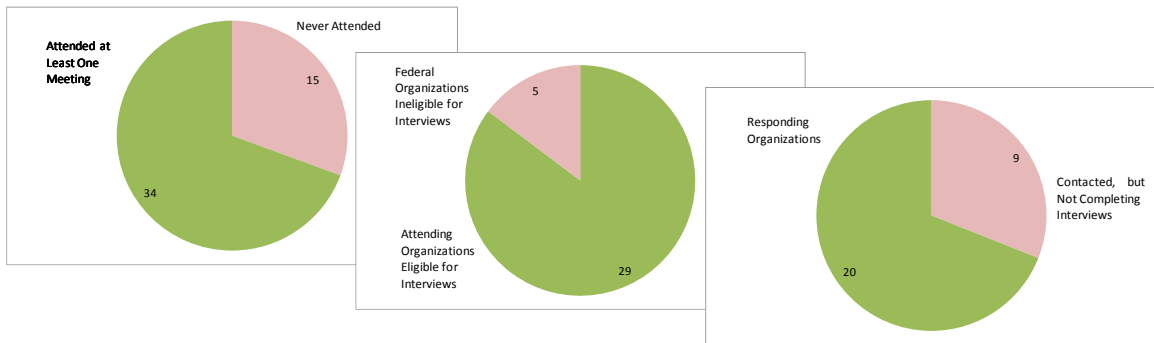
Figure A1-1: Interview Participation Summary

Appendix 2: General Results
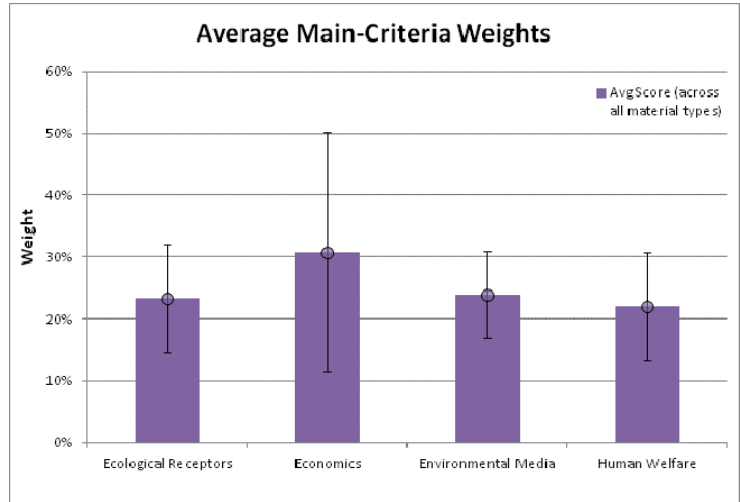
Figure A2-1: Average Main Criteria Weights Across All Material Types
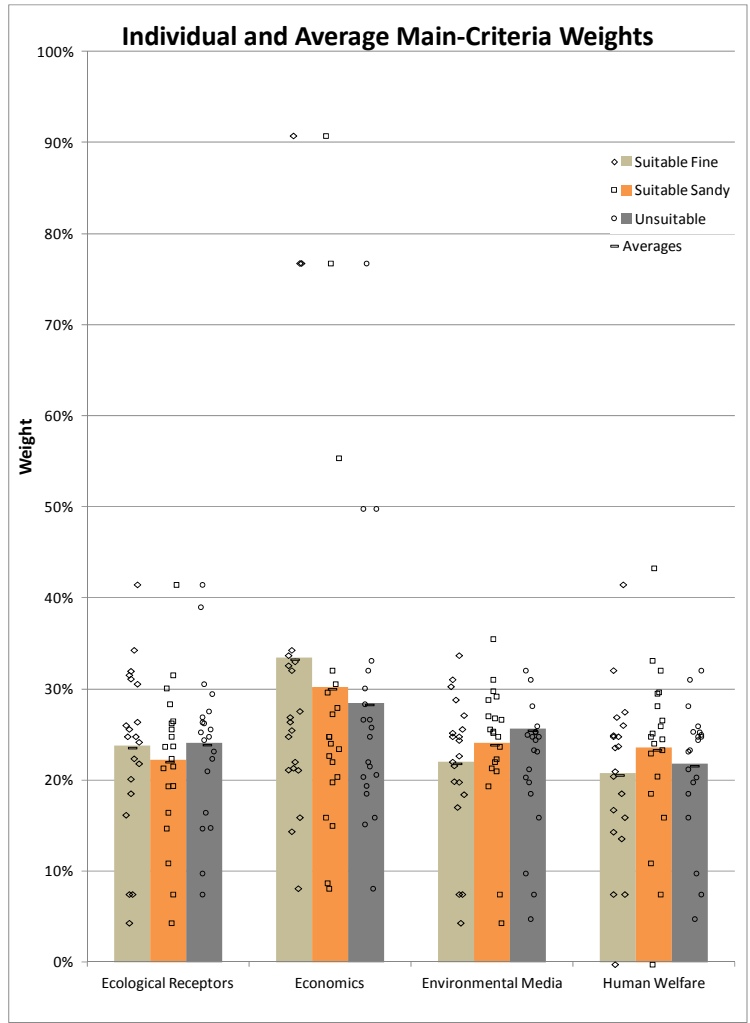
Figure A2-2: Average Main Criteria Weights Showing Outliers
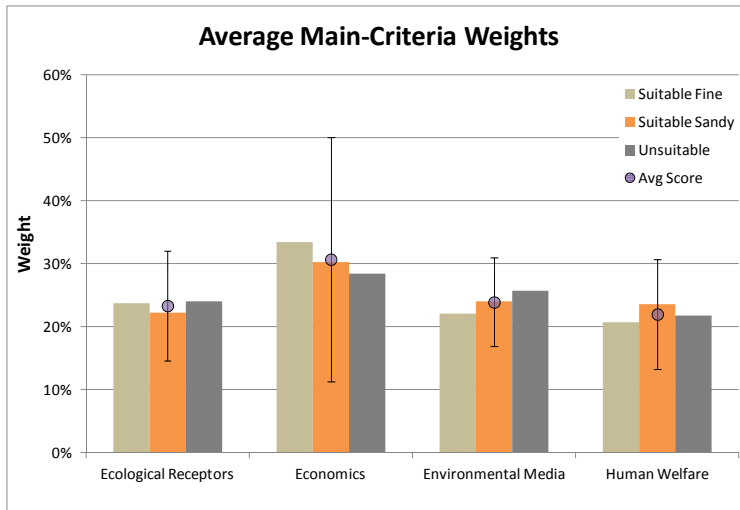
Figure A2-3: Average Main Criteria Weights
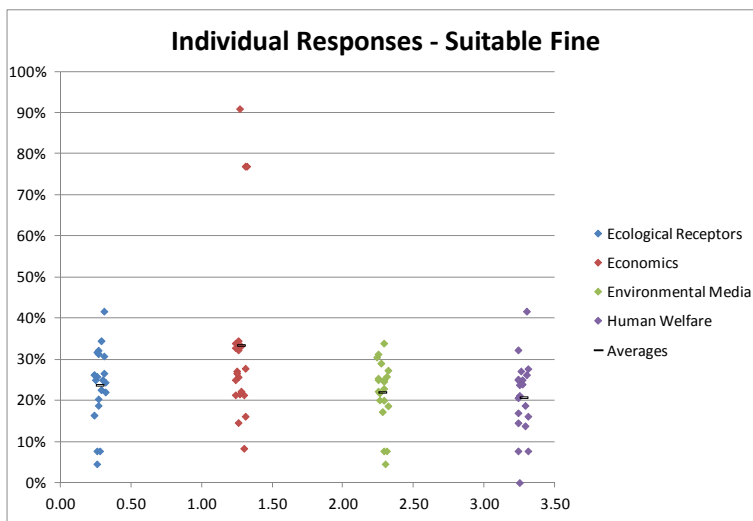
Figure A2-4: Individual Responses for Main Criteria (Fine)
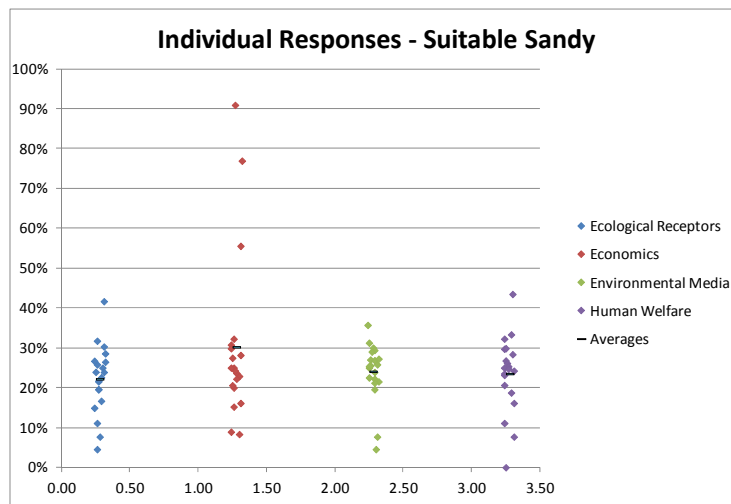
Figure A2-5: Individual Responses for Main Criteria (Sandy)
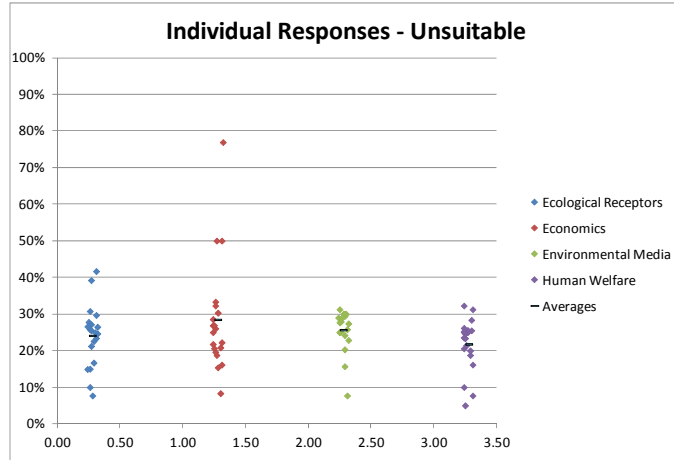
Figure A2-6: Individual Responses for Main Criteria (Unsuitable)
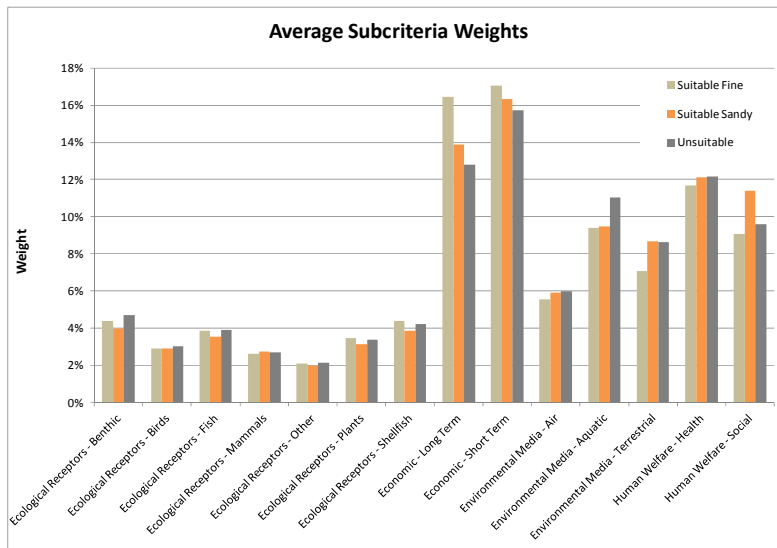
Figure A2-7: Average Sub-criteria Weights
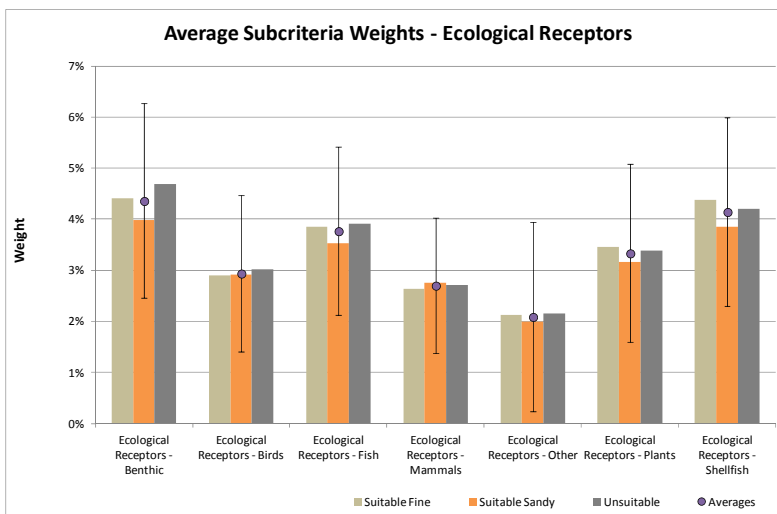
Figure A2-8: Average Sub-criteria Weights (Ecological Receptors)
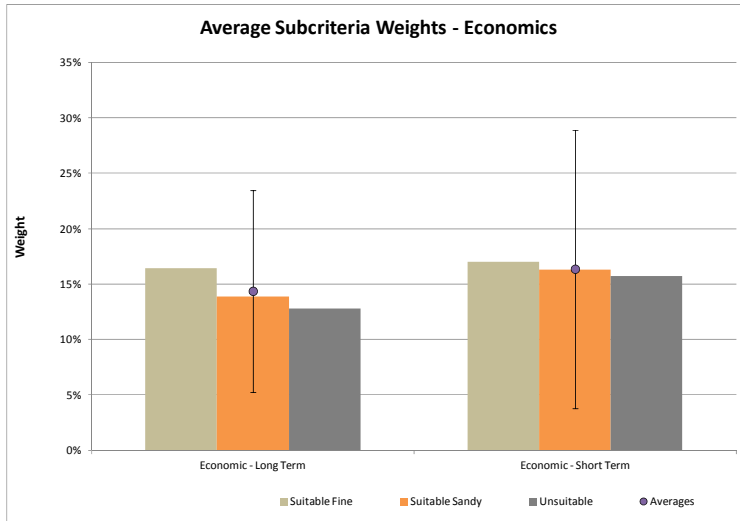
Figure A2-9: Average Sub-criteria Weights (Economics)
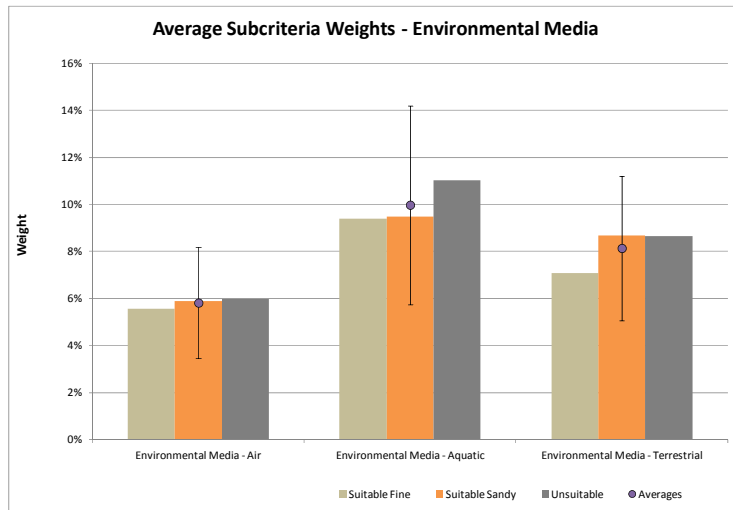
Figure A2-10: Average Sub-criteria Weights (Environmental Media)
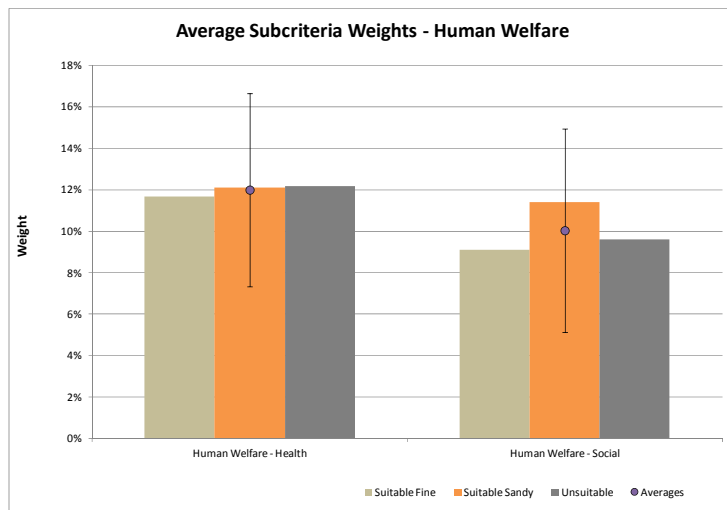
Figure A2-11: Average Sub-criteria Weights (Human Welfare)

Appendix 3: Results By State *(Blue=CT; Pink=NY; Purple=Other)*

Table A3-1: Subcriteria Weights (Fine)

Rank	Suitable Fine: Summary of Ranked List of Sub-Criteria Sub-Criterion	Total Weight		Rank	Suitable Fine: Summary of Ranked List of Sub-Criteria Sub-Criterion	Total Weight		Rank	Suitable Fine: Summary of Ranked List of Sub-Cr Sub-Criterion
1	Economic - Short Term	19.5%		1	Human Welfare - Health	12.9%		1	Environmental Media - Aquatic
2	Economic - Long Term	18.2%		2	Economic - Long Term	12.3%		2	Human Welfare - Health
3	Human Welfare - Health	11.5%		3	Human Welfare - Social	11.5%		3	Human Welfare - Social
4	Human Welfare - Social	8.5%		4	Economic - Short Term	10.8%		4	Economic - Long Term
5	Environmental Media - Aquatic	8.3%		5	Environmental Media - Aquatic	10.3%		5	Environmental Media - Terrestrial
6	Environmental Media - Terrestrial	6.5%		6	Environmental Media - Terrestrial	9.0%		6	Economic - Short Term
7	Environmental Media - Air	5.1%		7	Environmental Media - Air	8.4%		7	Ecological Receptors - Shellfish
8	Ecological Receptors - Benthic	4.2%		8	Ecological Receptors - Benthic	3.8%		8	Ecological Receptors - Benthic
9	Ecological Receptors - Shellfish	4.2%		9	Ecological Receptors - Plants	3.6%		9	Environmental Media - Air
10	Ecological Receptors - Fish	3.6%		10	Ecological Receptors - Shellfish	3.6%		10	Ecological Receptors - Fish
11	Ecological Receptors - Plants	3.4%		11	Ecological Receptors - Birds	3.5%		11	Ecological Receptors - Plants
12	Ecological Receptors - Birds	2.8%		12	Ecological Receptors - Fish	3.5%		12	Ecological Receptors - Other
13	Ecological Receptors - Mammals	2.4%		13	Ecological Receptors - Mammals	3.5%		13	Ecological Receptors - Mammals
14	Ecological Receptors - Other	1.7%		14	Ecological Receptors - Other	3.3%		14	Ecological Receptors - Birds

Table A3-2: Subcriteria Weights (Sandy)

Rank	Suitable Sandy: Summary of Ranked List of Sub-Criteria Sub-Criterion	Total Weight		Rank	Suitable Sandy: Summary of Ranked List of Sub-Criteria Sub-Criterion	Total Weight		Rank	Suitable Sandy: Summary of Ranked List of Sub-C Sub-Criterion
1	Economic - Short Term	19.0%		1	Human Welfare - Health	13.5%		1	Environmental Media - Aquatic
2	Economic - Long Term	15.3%		2	Human Welfare - Social	12.4%		2	Human Welfare - Health
3	Human Welfare - Health	12.1%		3	Environmental Media - Aquatic	10.8%		3	Human Welfare - Social
4	Human Welfare - Social	11.4%		4	Environmental Media - Terrestrial	10.1%		4	Economic - Long Term
5	Environmental Media - Aquatic	8.5%		5	Environmental Media - Air	9.5%		5	Environmental Media - Terrestrial
6	Environmental Media - Terrestrial	8.3%		6	Economic - Long Term	8.8%		6	Economic - Short Term
7	Environmental Media - Air	5.5%		7	Economic - Short Term	8.2%		7	Ecological Receptors - Shellfish
8	Ecological Receptors - Benthic	3.6%		8	Ecological Receptors - Birds	4.1%		8	Ecological Receptors - Benthic
9	Ecological Receptors - Shellfish	3.4%		9	Ecological Receptors - Fish	4.0%		9	Environmental Media - Air
10	Ecological Receptors - Fish	3.1%		10	Ecological Receptors - Mammals	4.0%		10	Ecological Receptors - Fish
11	Ecological Receptors - Plants	2.9%		11	Ecological Receptors - Plants	3.8%		11	Ecological Receptors - Plants
12	Ecological Receptors - Birds	2.8%		12	Ecological Receptors - Benthic	3.7%		12	Ecological Receptors - Other
13	Ecological Receptors - Mammals	2.6%		13	Ecological Receptors - Shellfish	3.7%		13	Ecological Receptors - Mammals
14	Ecological Receptors - Other	1.6%		14	Ecological Receptors - Other	3.5%		14	Ecological Receptors - Birds

**Table A3-3: Subcriteria Weights (Unsuitable)**

Unsuitable: Summary of Ranked List of Sub-Criteria				Unsuitable: Summary of Ranked List of Sub-Criteria				Unsuitable: Summary of Ranked List of Sub-Criteria	
Rank	Sub-Criterion	Total Weight		Rank	Sub-Criterion	Total Weight		Rank	Sub-Criterion
1	Economic - Short Term	17.6%		1	Human Welfare - Health	12.9%		1	Environmental Media - Aquatic
2	Economic - Long Term	13.4%		2	Economic - Long Term	12.5%		2	Human Welfare - Health
3	Human Welfare - Health	11.8%		3	Human Welfare - Social	11.9%		3	Environmental Media - Terrestrial
4	Environmental Media - Aquatic	10.6%		4	Economic - Short Term	10.9%		4	Economic - Long Term
5	Human Welfare - Social	9.4%		5	Environmental Media - Aquatic	9.9%		5	Economic - Short Term
6	Environmental Media - Terrestrial	8.3%		6	Environmental Media - Terrestrial	9.3%		6	Human Welfare - Social
7	Environmental Media - Air	5.9%		7	Environmental Media - Air	7.9%		7	Ecological Receptors - Benthic
8	Ecological Receptors - Benthic	4.6%		8	Ecological Receptors - Benthic	3.9%		8	Ecological Receptors - Fish
9	Ecological Receptors - Shellfish	4.1%		9	Ecological Receptors - Plants	3.6%		9	Ecological Receptors - Shellfish
10	Ecological Receptors - Fish	3.6%		10	Ecological Receptors - Shellfish	3.6%		10	Environmental Media - Air
11	Ecological Receptors - Plants	3.3%		11	Ecological Receptors - Fish	3.5%		11	Ecological Receptors - Plants
12	Ecological Receptors - Birds	2.9%		12	Ecological Receptors - Birds	3.4%		12	Ecological Receptors - Birds
13	Ecological Receptors - Mammals	2.6%		13	Ecological Receptors - Mammals	3.4%		13	Ecological Receptors - Other
14	Ecological Receptors - Other	1.8%		14	Ecological Receptors - Other	3.2%		14	Ecological Receptors - Mammals
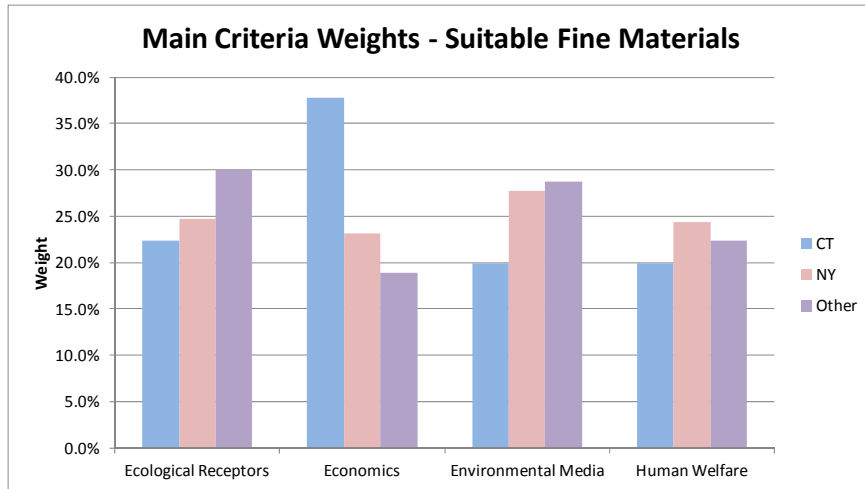
Figure A3-1: Main Criteria Weights
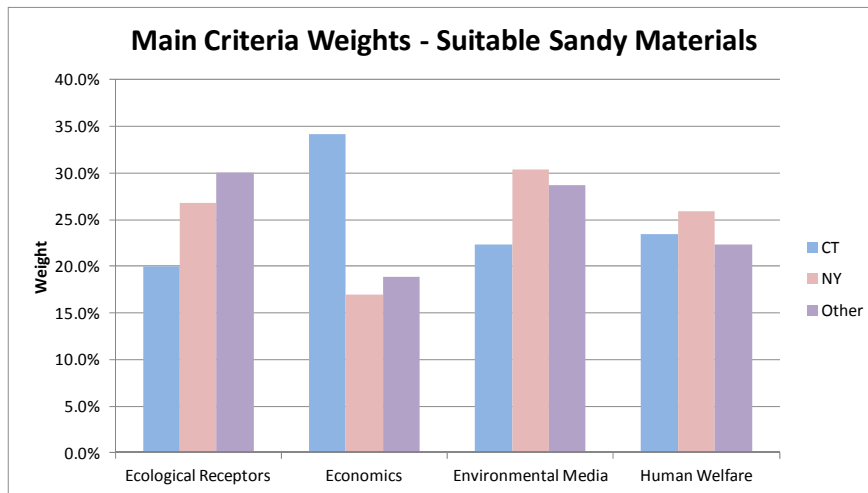
Figure A3-2: Main Criteria Weights
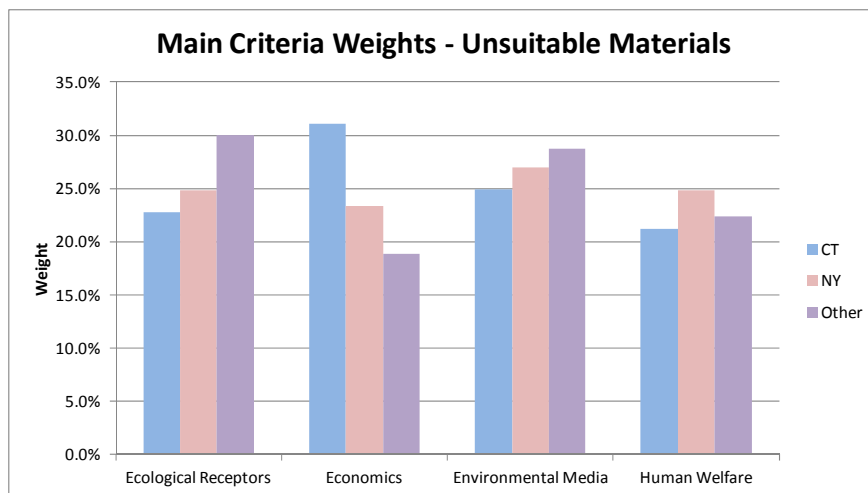
Figure A3-3: Main Criteria Weights
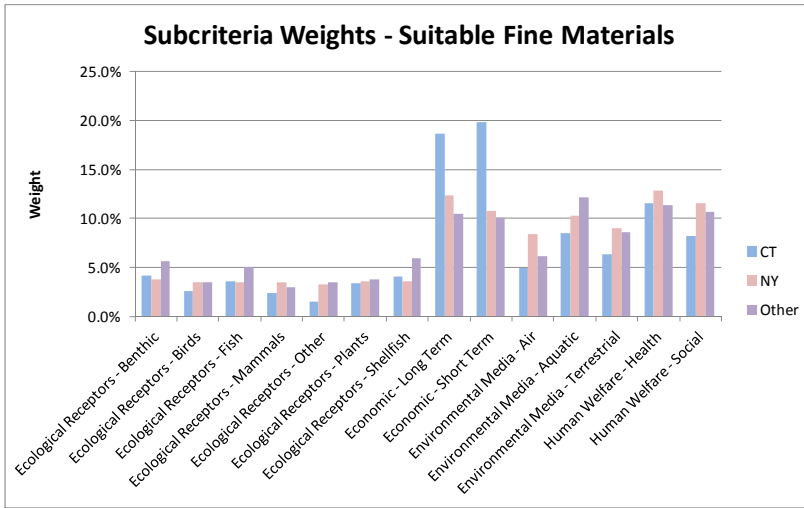
Figure A3-4: Sub-criteria Weights
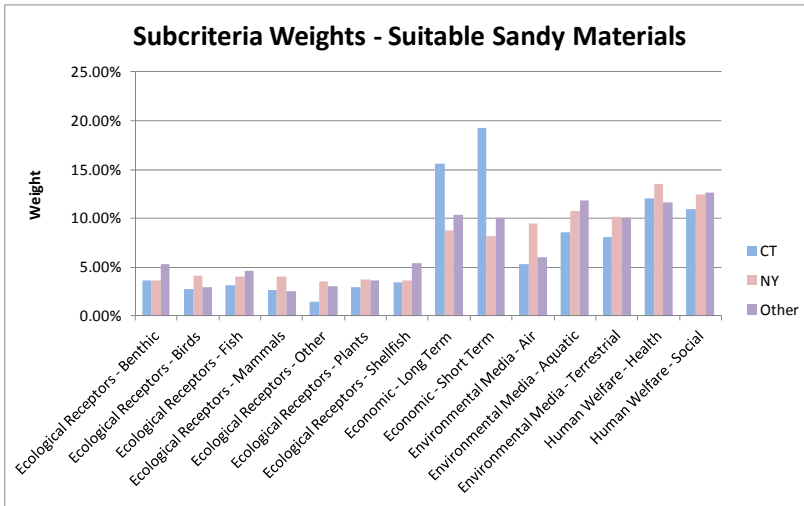
Figure A3-5: Sub-criteria Weights
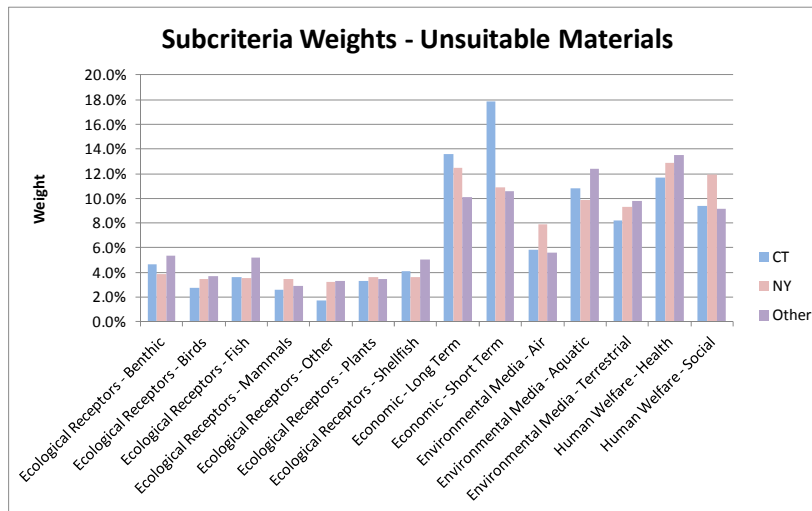
Figure A3-6: Sub-criteria Weights

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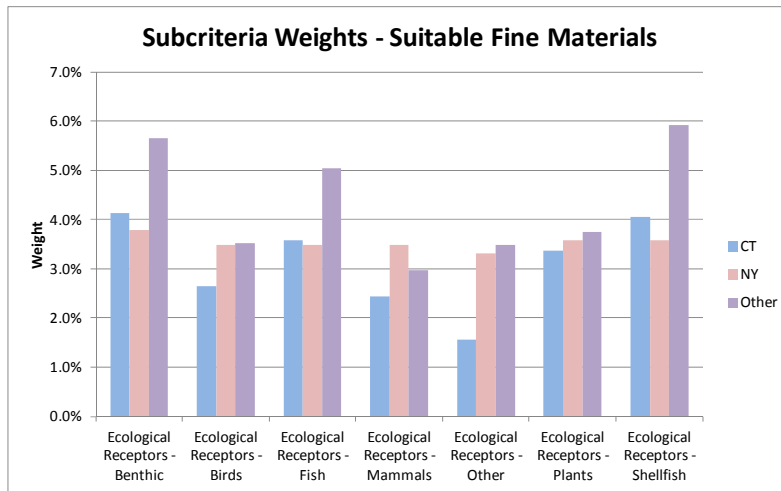
Figure A3-7: Sub-criteria Weights (Ecological Receptors)
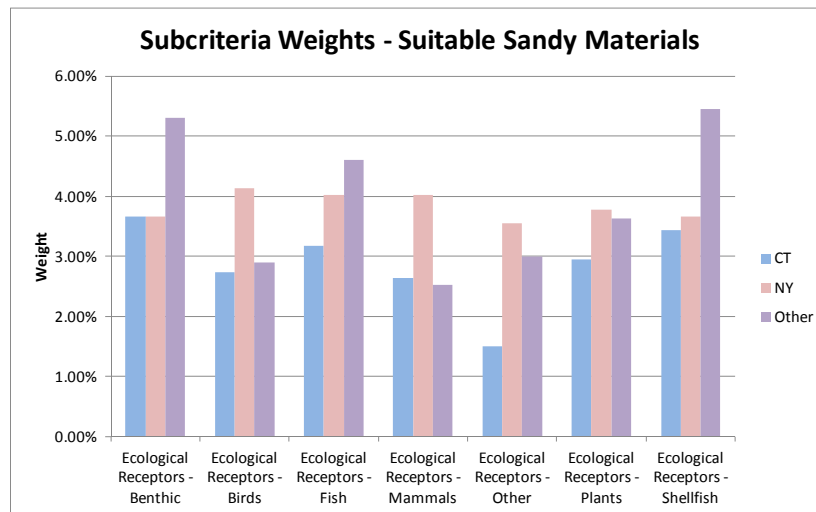
Figure A3-8: Sub-criteria Weights (Ecological Receptors)
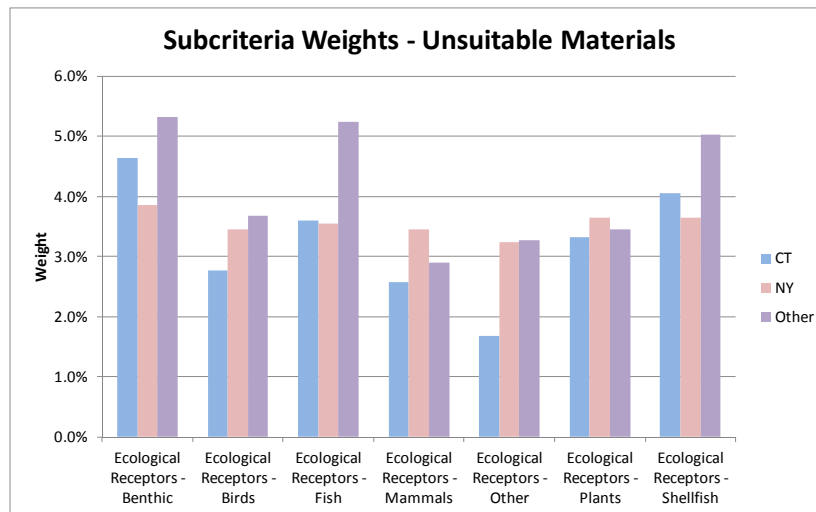
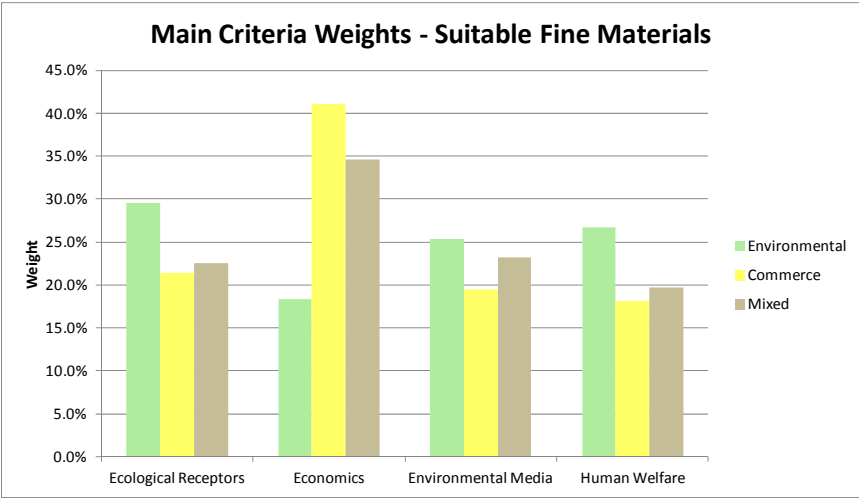**Figure A3-9: Sub-criteria Weights (Ecological Receptors)**
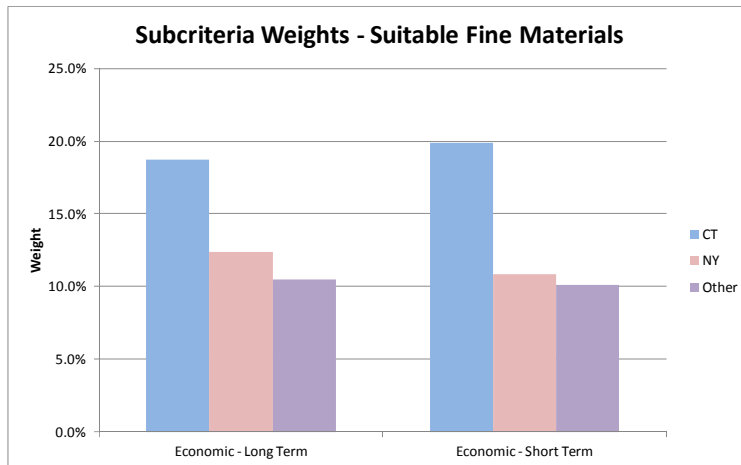
Figure A3-10: Sub-criteria Weights (Economics)
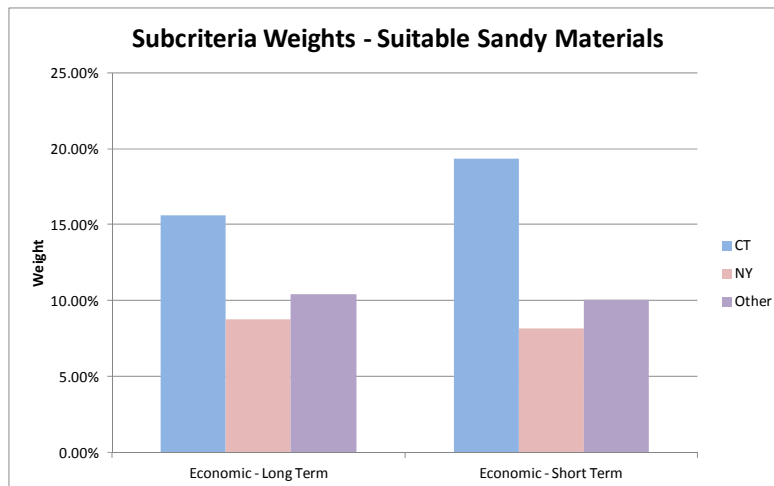
Figure A3-11: Sub-criteria Weights (Economics)
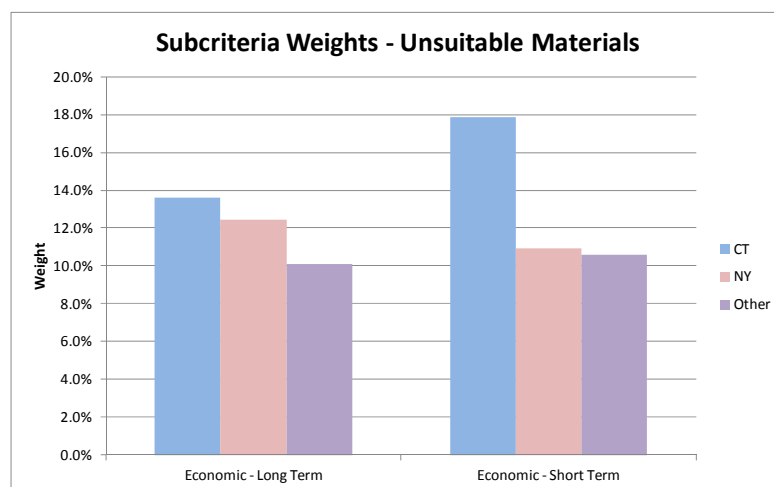
Figure A3-12: Sub-criteria Weights (Economics)
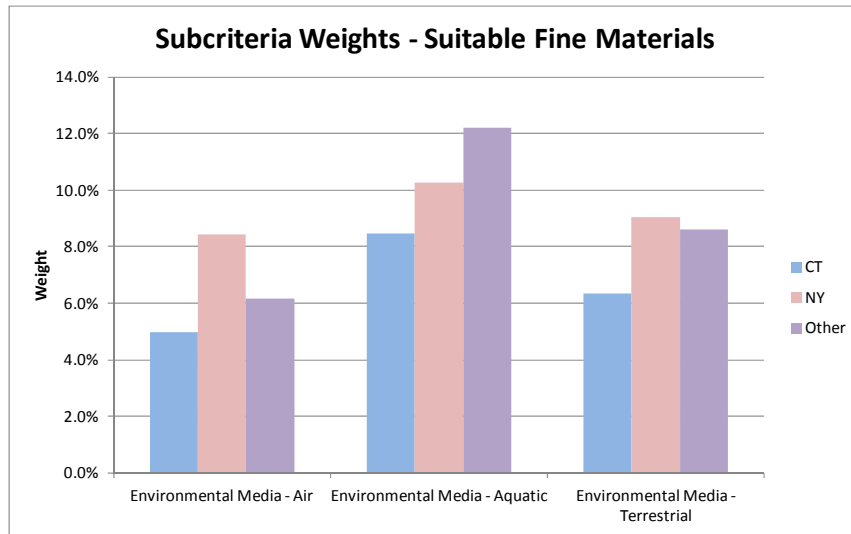
Figure A3-13: Sub-criteria Weights (Environmental Media)
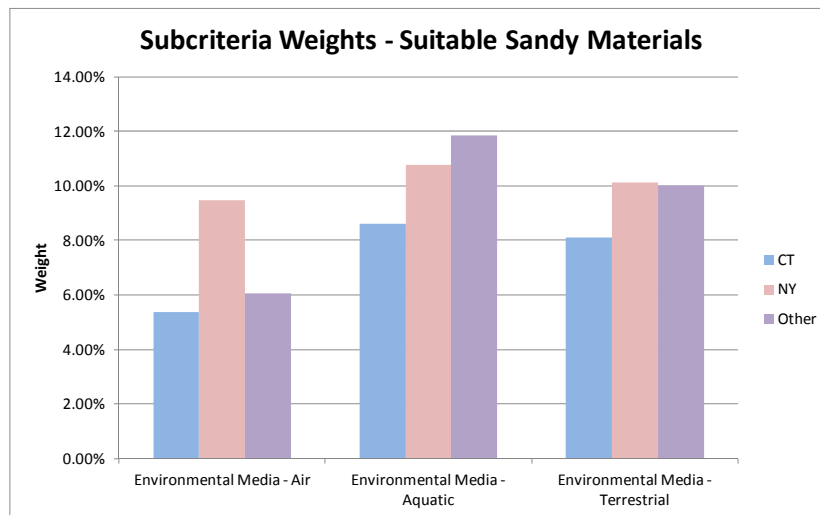
Figure A3-14: Sub-criteria Weights (Environmental Media)
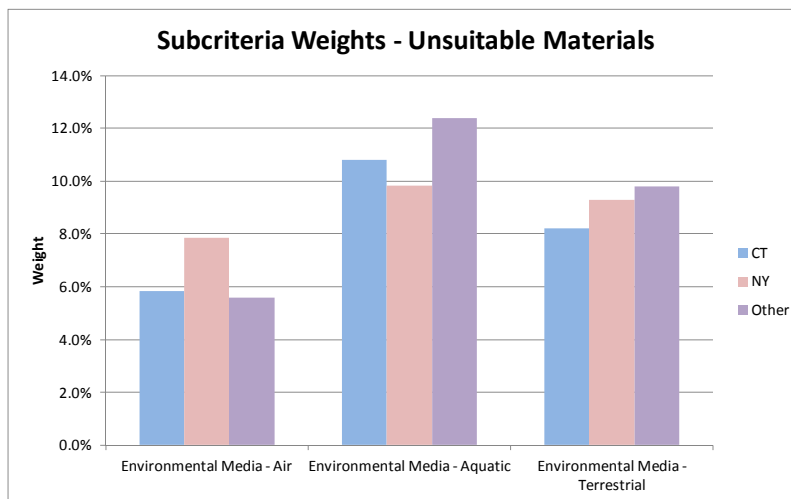
Figure A3-15: Sub-criteria Weights (Environmental Media)
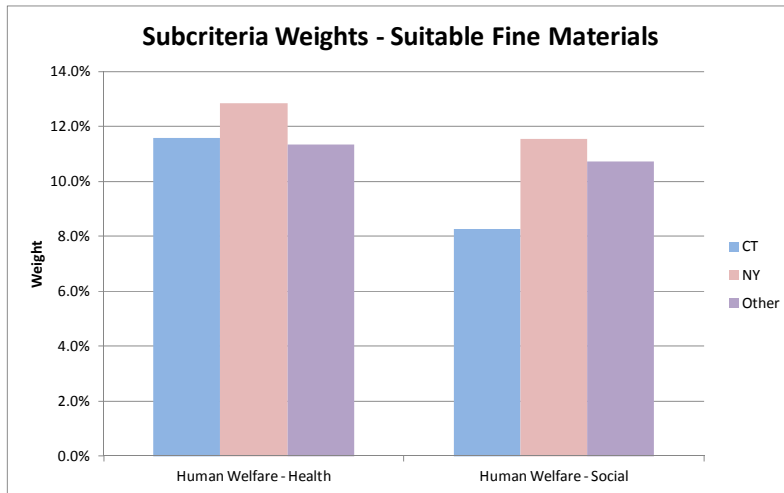
Figure A3-16: Sub-criteria Weights (Human Welfare)
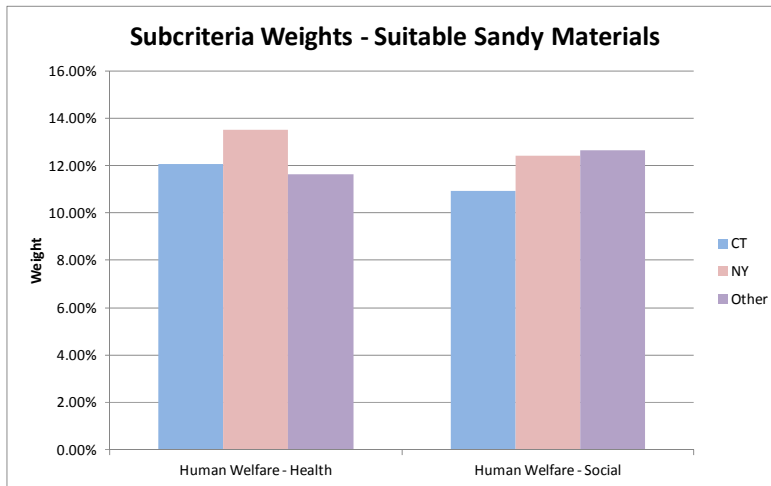
Figure A3-17: Sub-criteria Weights (Human Welfare)
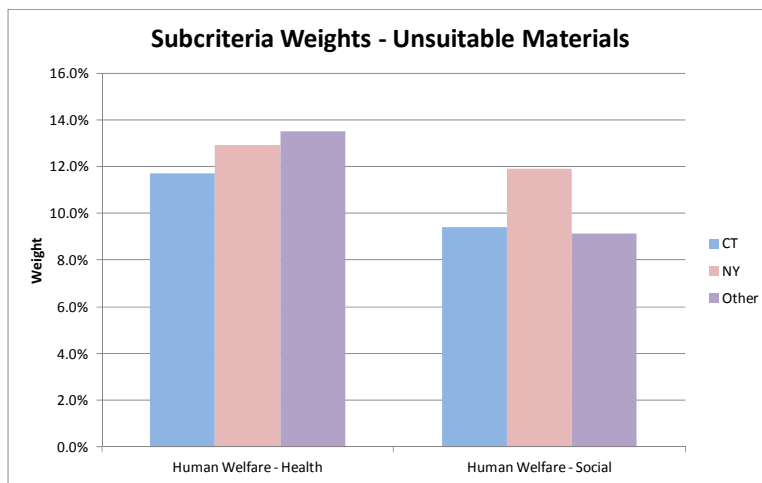
Figure A3-18: Sub-criteria Weights (Environmental Media)
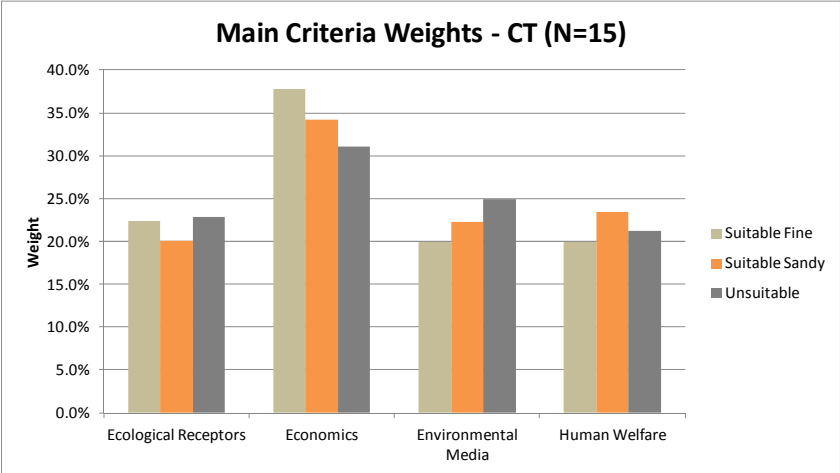
Figure A3-19: Main Criteria Weights (CT)
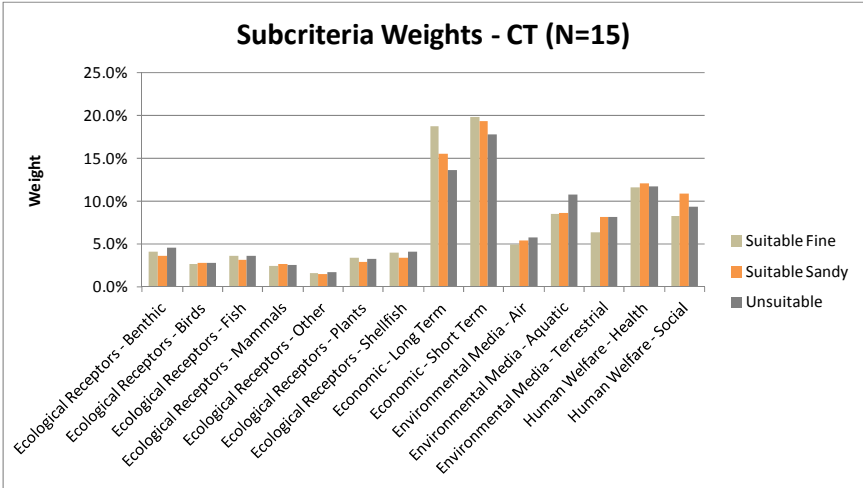
Figure A3-20: Sub-criteria Weights (CT)
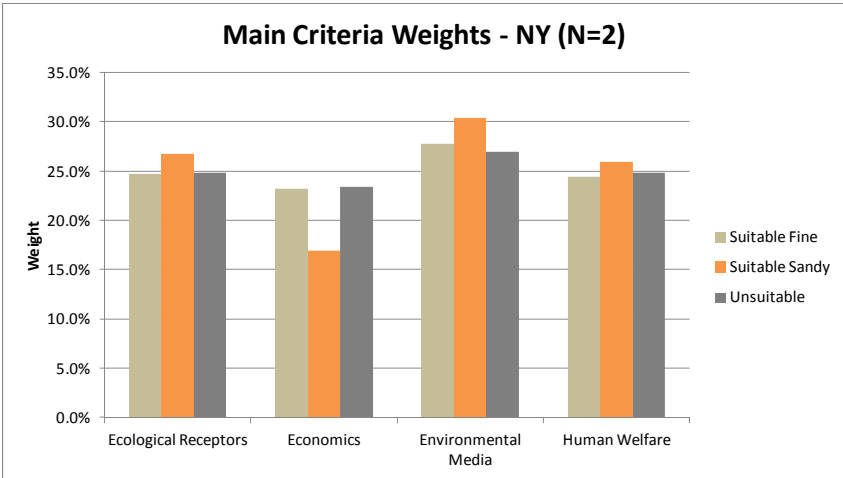
Figure A3-21: Main Criteria Weights (NY)
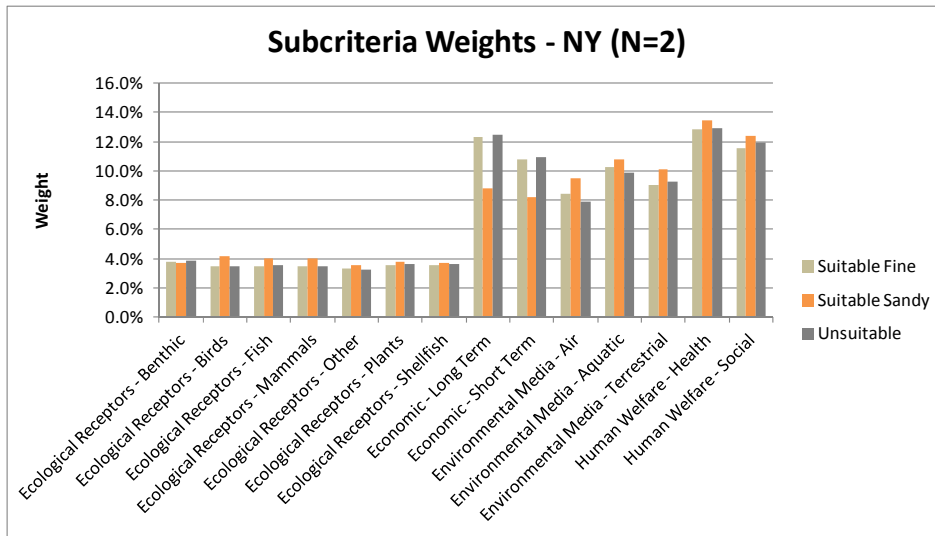
Figure A3-22: Sub-criteria Weights (NY)
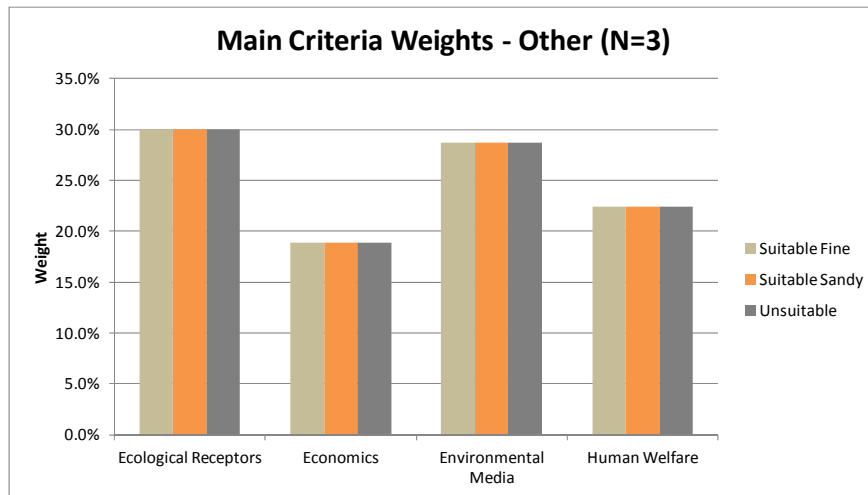
Figure A3-23: Main Criteria Weights (Other)
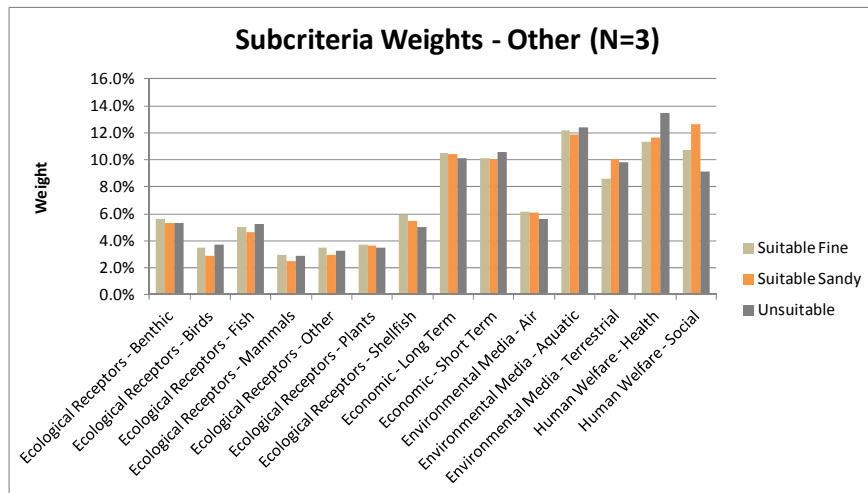
Figure A3-24: Sub-criteria Weights (Other)

Appendix 4: Results by Organizational Mission *(Green=Environmental; Yellow=Commerce; Brown=Mixed)*

Table A4-1: Sub-criteria Weights (Fine)

| Rank	Suitable Fine: Summary of Ranked List of Sub-Criteria — Sub-Criterion	Total Weight	Rank	Suitable Fine: Summary of Ranked List of Sub-Criteria — Sub-Criterion	Total Weight	Rank	Suitable Fine: Summary of Ranked List of Sub-Criteria — Sub-Criterion	Total Weig
1	Human Welfare - Health	14.26%	1	Economic - Long Term	21.27%	1	Economic - Short Term	19.75%
2	Human Welfare - Social	12.49%	2	Economic - Short Term	19.82%	2	Economic - Long Term	14.86%
3	Environmental Media - Aquatic	11.54%	3	Human Welfare - Health	11.28%	3	Human Welfare - Health	10.11%
4	Economic - Long Term	9.60%	4	Environmental Media - Aquatic	8.15%	4	Human Welfare - Social	9.64%
5	Economic - Short Term	8.73%	5	Human Welfare - Social	6.83%	5	Environmental Media - Aquatic	9.51%
6	Environmental Media - Terrestrial	7.88%	6	Environmental Media - Terrestrial	6.39%	6	Environmental Media - Terrestrial	7.43%
7	Environmental Media - Air	5.91%	7	Environmental Media - Air	4.90%	7	Environmental Media - Air	6.23%
8	Ecological Receptors - Shellfish	4.98%	8	Ecological Receptors - Benthic	4.37%	8	Ecological Receptors - Shellfish	4.14%
9	Ecological Receptors - Benthic	4.90%	9	Ecological Receptors - Shellfish	4.19%	9	Ecological Receptors - Benthic	4.04%
10	Ecological Receptors - Fish	4.58%	10	Ecological Receptors - Fish	3.69%	10	Ecological Receptors - Fish	3.51%
11	Ecological Receptors - Plants	4.49%	11	Ecological Receptors - Plants	3.32%	11	Ecological Receptors - Birds	3.20%
12	Ecological Receptors - Other	4.05%	12	Ecological Receptors - Birds	2.44%	12	Ecological Receptors - Plants	2.82%
13	Ecological Receptors - Birds	3.37%	13	Ecological Receptors - Mammals	2.28%	13	Ecological Receptors - Mammals	2.71%
14	Ecological Receptors - Mammals	3.21%	14	Ecological Receptors - Other	1.09%	14	Ecological Receptors - Other	2.06%

Table A4-2: Subcriteria Weights (Sandy)

Rank	Suitable Sandy: Summary of Ranked List of Sub-Criteria — Sub-Criterion	Total Weight	Rank	Suitable Sandy: Summary of Ranked List of Sub-Criteria — Sub-Criterion	Total Weight	Rank	Suitable Sandy: Summary of Ranked List of Sub-Criteria — Sub-Criterion	Total Weig
1	Human Welfare - Health	13.79%	1	Economic - Short Term	18.72%	1	Economic - Short Term	18.47%
2	Human Welfare - Social	12.63%	2	Economic - Long Term	16.05%	2	Economic - Long Term	14.21%
3	Environmental Media - Aquatic	10.29%	3	Human Welfare - Health	12.28%	3	Human Welfare - Social	10.91%
4	Economic - Long Term	9.53%	4	Human Welfare - Social	11.05%	4	Human Welfare - Health	10.46%
5	Economic - Short Term	9.47%	5	Environmental Media - Aquatic	9.07%	5	Environmental Media - Aquatic	9.42%
6	Environmental Media - Terrestrial	8.63%	6	Environmental Media - Terrestrial	8.69%	6	Environmental Media - Terrestrial	8.75%
7	Environmental Media - Air	5.56%	7	Environmental Media - Air	5.71%	7	Environmental Media - Air	6.48%
8	Ecological Receptors - Shellfish	5.05%	8	Ecological Receptors - Benthic	3.59%	8	Ecological Receptors - Shellfish	3.88%
9	Ecological Receptors - Benthic	4.94%	9	Ecological Receptors - Shellfish	3.17%	9	Ecological Receptors - Benthic	3.80%
10	Ecological Receptors - Fish	4.66%	10	Ecological Receptors - Fish	3.01%	10	Ecological Receptors - Fish	3.38%
11	Ecological Receptors - Plants	4.24%	11	Ecological Receptors - Plants	2.81%	11	Ecological Receptors - Birds	2.99%
12	Ecological Receptors - Other	4.09%	12	Ecological Receptors - Mammals	2.56%	12	Ecological Receptors - Plants	2.80%
13	Ecological Receptors - Birds	3.86%	13	Ecological Receptors - Birds	2.33%	13	Ecological Receptors - Mammals	2.61%
14	Ecological Receptors - Mammals	3.26%	14	Ecological Receptors - Other	0.95%	14	Ecological Receptors - Other	1.82%

Table A4-3: Subcriteria Weights (Unsuitable)

| Rank	Sub-Criterion	Total Weight		Rank	Sub-Criterion	Total Weight		Rank	Sub-Criterion	Total Weight
	Unsuitable: Summary of Ranked List of Sub-Criteria				Unsuitable: Summary of Ranked List of Sub-Criteria				Unsuitable: Summary of Ranked List of Sub-Criteria	
1	Human Welfare - Health	15.12%		1	Economic - Short Term	21.04%		1	Economic - Short Term	14.08%
2	Environmental Media - Aquatic	10.47%		2	Economic - Long Term	14.04%		2	Economic - Long Term	13.75%
3	Human Welfare - Social	10.21%		3	Human Welfare - Health	10.71%		3	Environmental Media - Aquatic	12.85%
4	Economic - Long Term	9.37%		4	Environmental Media - Aquatic	10.15%		4	Human Welfare - Health	11.91%
5	Economic - Short Term	8.05%		5	Human Welfare - Social	9.52%		5	Human Welfare - Social	9.19%
6	Environmental Media - Terrestrial	7.84%		6	Environmental Media - Terrestrial	8.80%		6	Environmental Media - Terrestrial	9.06%
7	Environmental Media - Air	5.68%		7	Environmental Media - Air	6.26%		7	Environmental Media - Air	5.81%
8	Ecological Receptors - Shellfish	5.58%		8	Ecological Receptors - Benthic	4.43%		8	Ecological Receptors - Benthic	4.73%
9	Ecological Receptors - Plants	5.39%		9	Ecological Receptors - Fish	3.31%		9	Ecological Receptors - Shellfish	4.45%
10	Ecological Receptors - Fish	5.30%		10	Ecological Receptors - Shellfish	3.29%		10	Ecological Receptors - Fish	3.66%
11	Ecological Receptors - Benthic	5.11%		11	Ecological Receptors - Plants	2.75%		11	Ecological Receptors - Birds	3.31%
12	Ecological Receptors - Other	4.25%		12	Ecological Receptors - Birds	2.27%		12	Ecological Receptors - Plants	2.65%
13	Ecological Receptors - Birds	4.00%		13	Ecological Receptors - Mammals	2.25%		13	Ecological Receptors - Mammals	2.65%
14	Ecological Receptors - Mammals	3.63%		14	Ecological Receptors - Other	1.16%		14	Ecological Receptors - Other	1.90%

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Figure A4-1: Main Criteria Weights
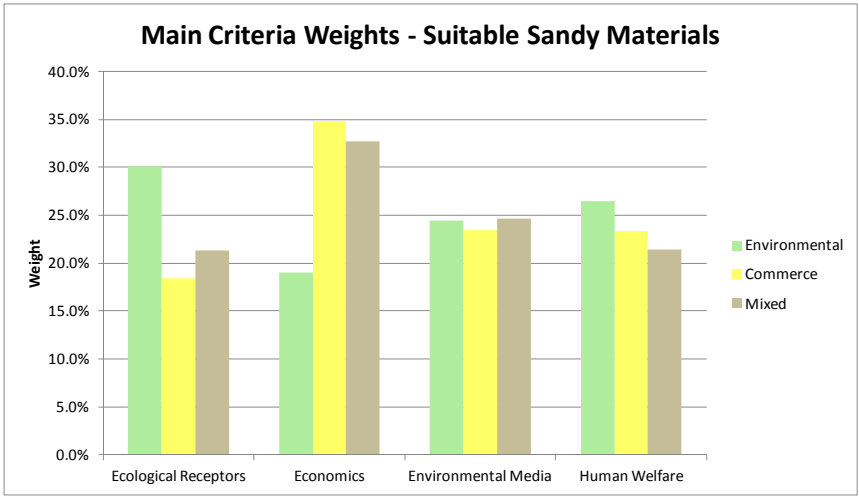
Figure A4-2: Main Criteria Weights
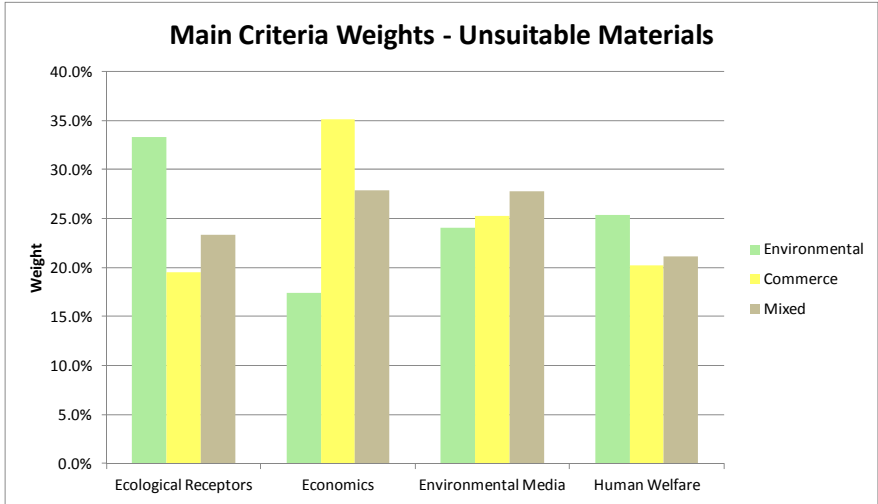
Figure A4-3: Main Criteria Weights
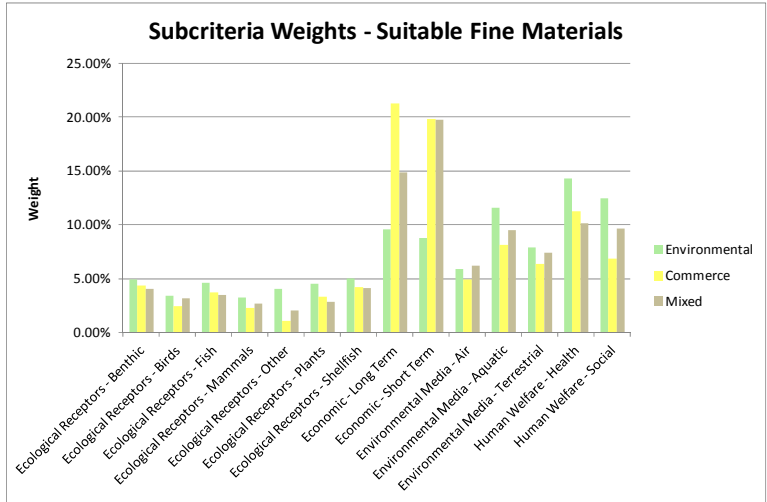
Figure A4-4: Sub-criteria Weights
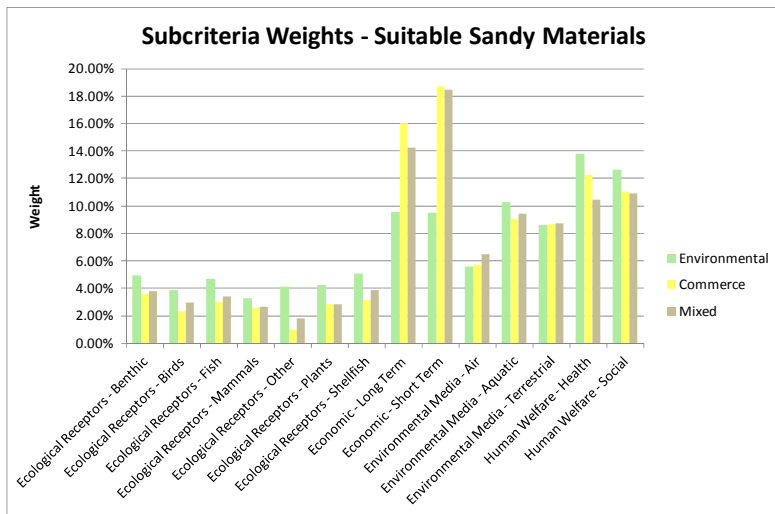
Figure A4-5: Sub-criteria Weights
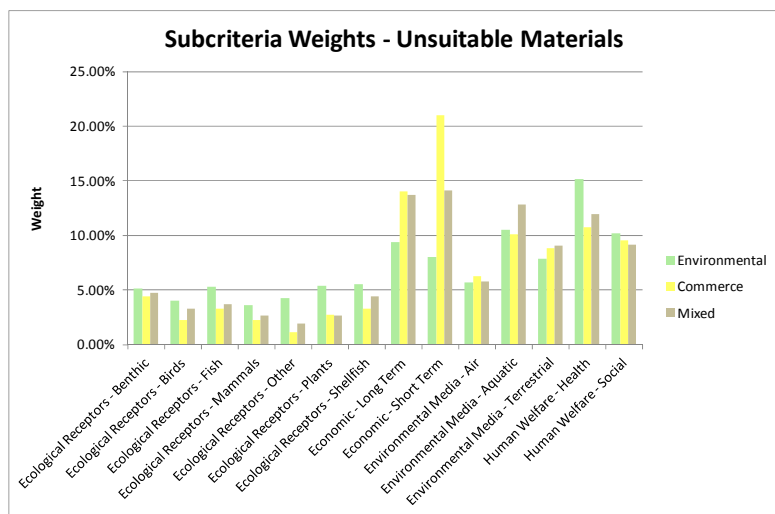
Figure A4-6: Sub-criteria Weights

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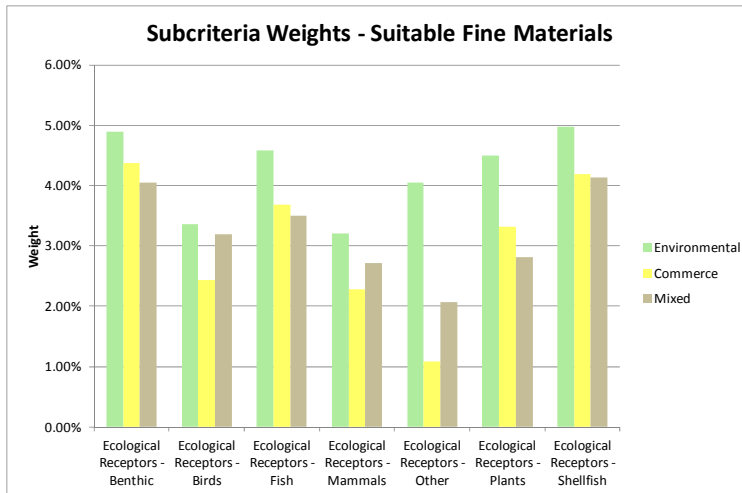
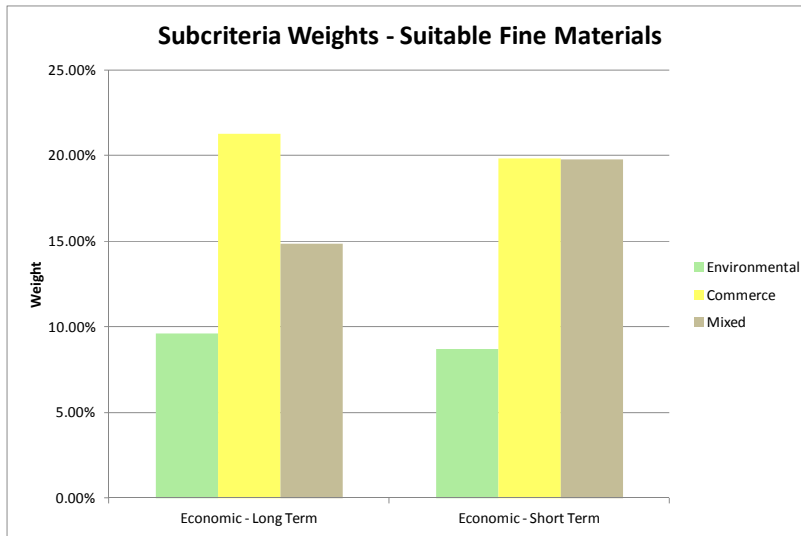**Figure A4-7: Sub-criteria Weights (Ecological Receptors)**
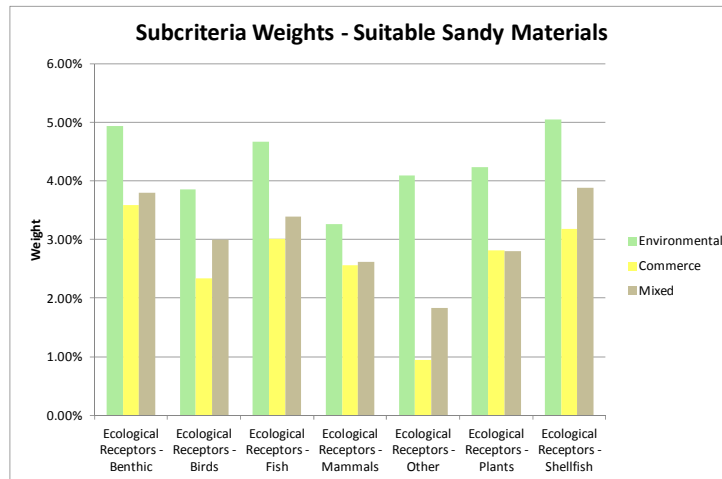
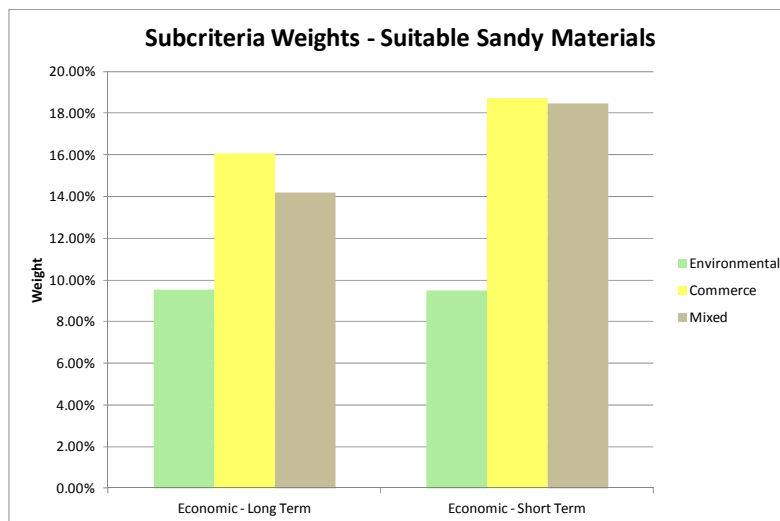**Figure A4-8: Sub-criteria Weights (Ecological Receptors)**
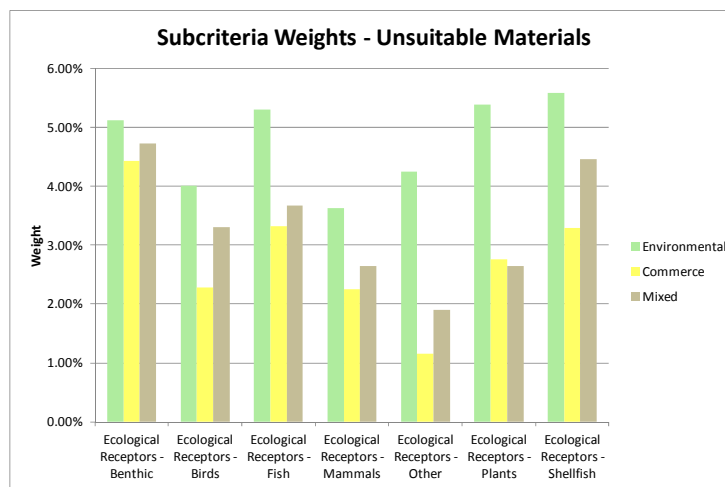
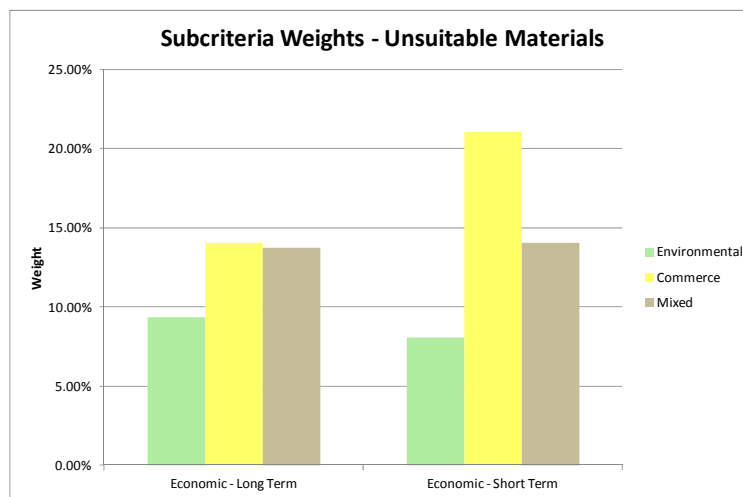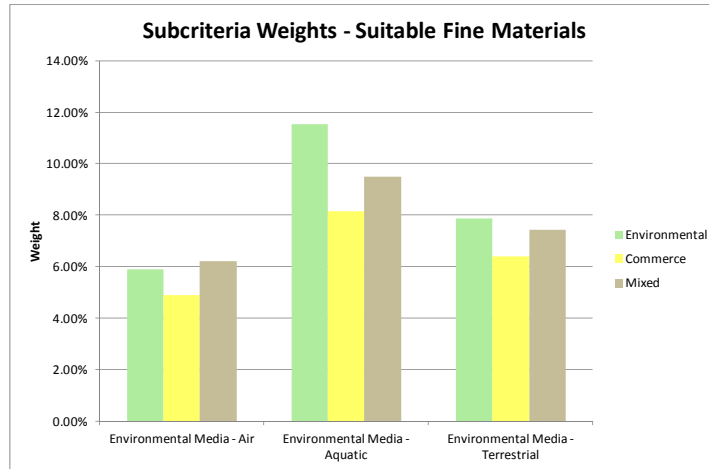**Figure A4-9: Sub-criteria Weights (Ecological Receptors)**

Figure A4-10: Sub-criteria Weights (Economics)

Figure A4-11: Sub-criteria Weights (Economics)

Figure A4-12: Sub-criteria Weights (Economics)

Figure A4-13: Sub-criteria Weights (Environmental Media)
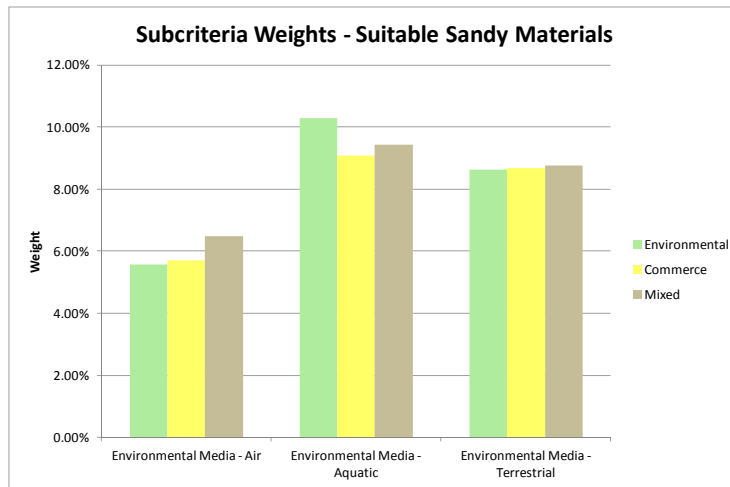
Figure A4-14: Sub-criteria Weights (Environmental Media)
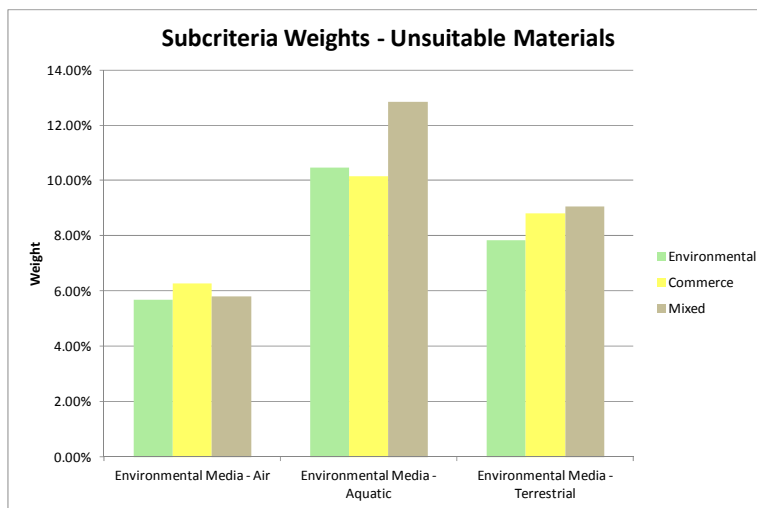
Figure A4-15: Sub-criteria Weights (Environmental Media)
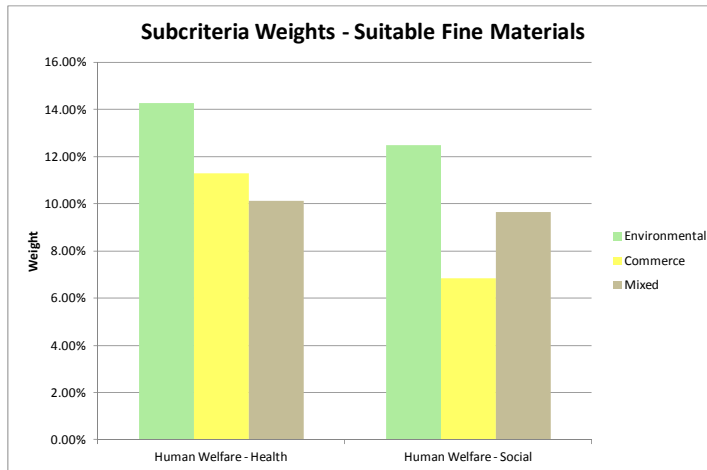
Figure A4-16: Sub-criteria Weights (Human Welfare)
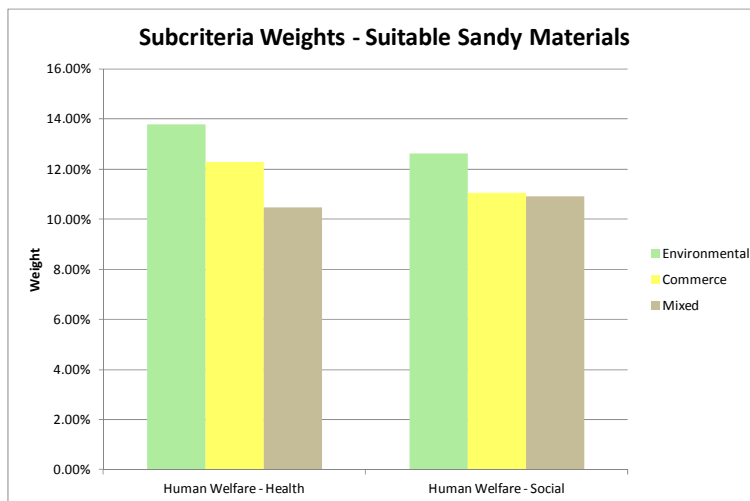
Figure A4-17: Sub-criteria Weights (Human Welfare)
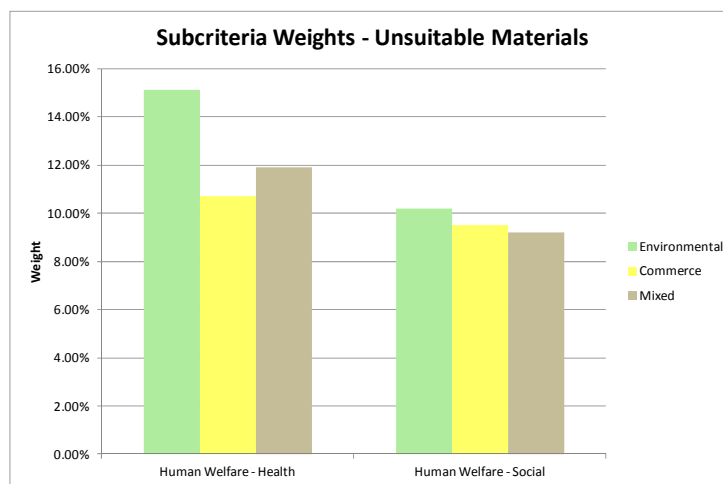
Figure A4-18: Sub-criteria Weights (Human Welfare)
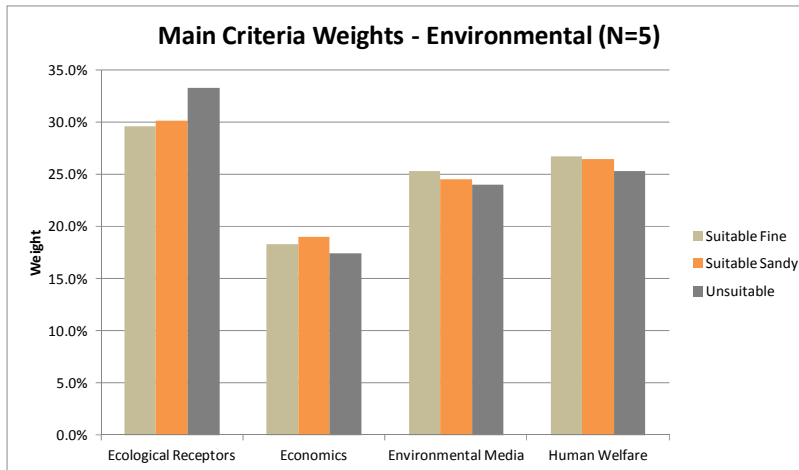
Figure A4-19: Main Criteria Weights (Environmental)
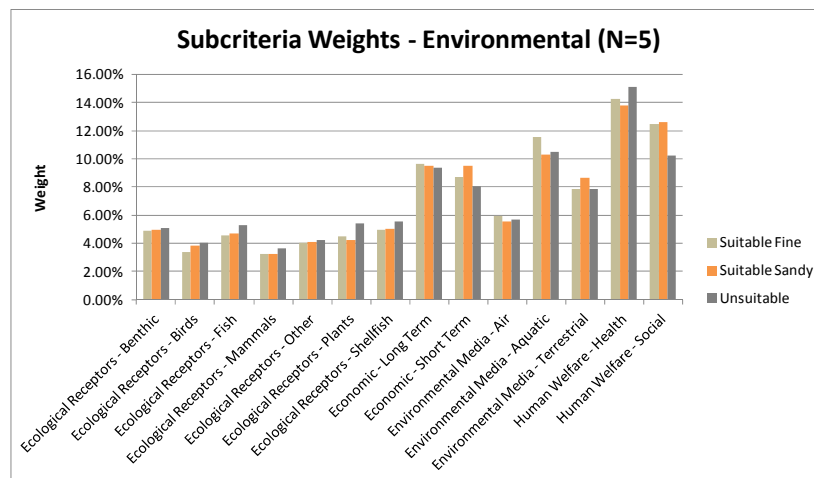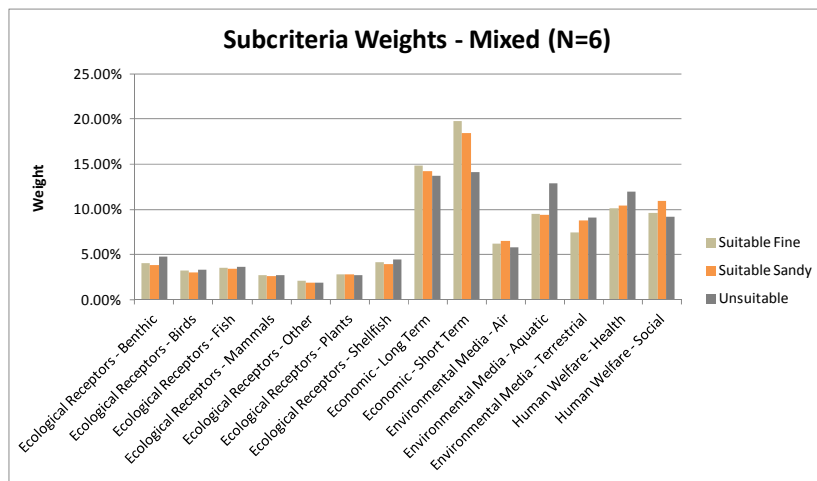

Figure A4-20: Sub-criteria Weights (Environmental)
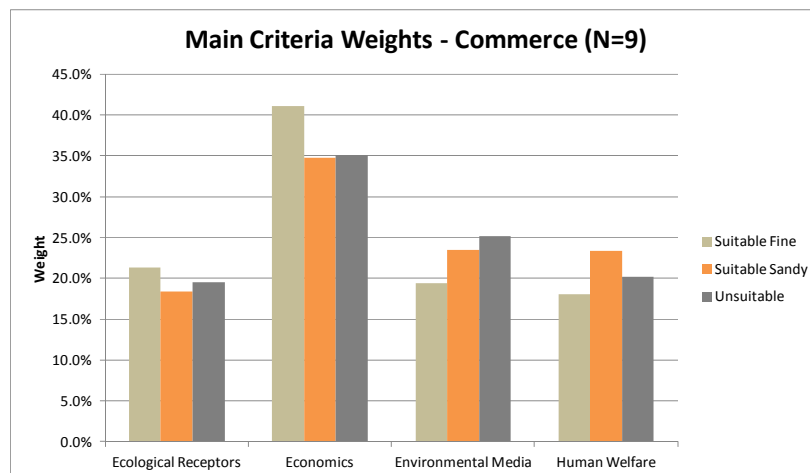
Figure A4-21: Main Criteria Weights (Commerce)
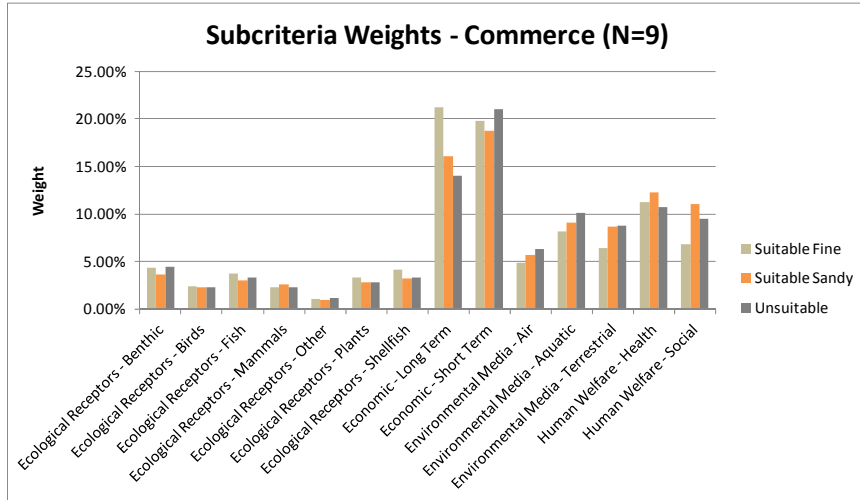
Figure A4-22: Main Criteria Weights (Commerce)
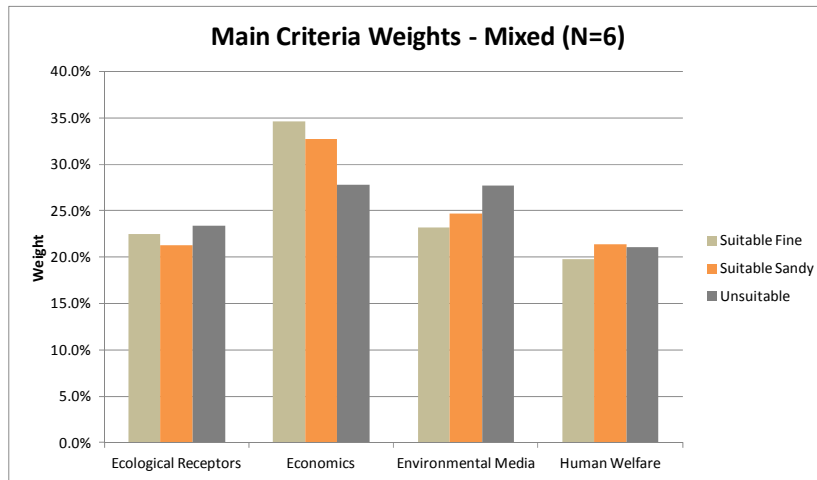
Figure A4-23: Main Criteria Weights (Mixed)

Figure A4-24: Sub-criteria Weights (Mixed)

Appendix 5: Results by Organizational Sector *(Orange=Federal/State; Blue=Local/Regional; Pink=NGO)*
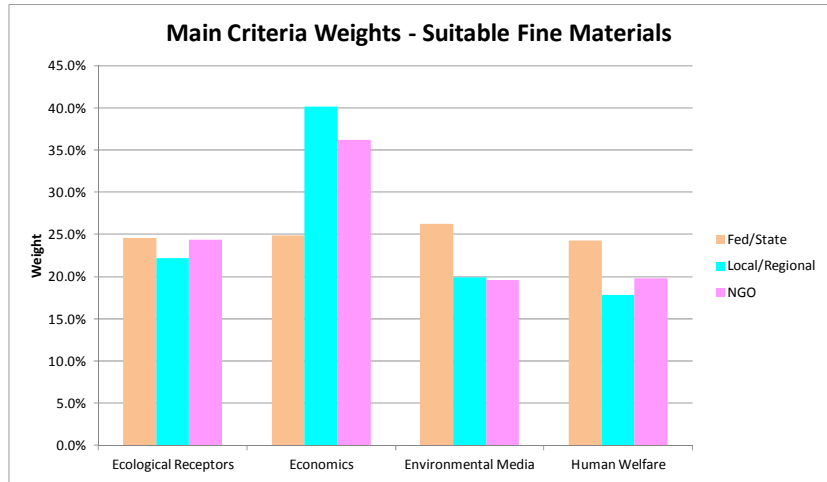
Table A5-1: Sub-criteria Weights (Fine)

| Rank	Sub-Criterion	Total Weight		Rank	Sub-Criterion	Total Weight		Rank	Sub-Criterion	Total Weight
	Suitable Fine: Summary of Ranked List of Sub-Criteria				Suitable Fine: Summary of Ranked List of Sub-Criteria				Suitable Fine: Summary of Ranked List of Sub-Criteria	
1	Economic - Short Term	12.66%		1	Economic - Short Term	22.61%		1	Economic - Long Term	19.64%
2	Human Welfare - Health	12.42%		2	Economic - Long Term	17.52%		2	Economic - Short Term	16.60%
3	Economic - Long Term	12.27%		3	Human Welfare - Health	11.00%		3	Human Welfare - Health	11.50%
4	Human Welfare - Social	11.82%		4	Environmental Media - Aquatic	8.67%		4	Environmental Media - Aquatic	9.39%
5	Environmental Media - Aquatic	10.04%		5	Human Welfare - Social	6.80%		5	Human Welfare - Social	8.30%
6	Environmental Media - Terrestrial	8.96%		6	Environmental Media - Terrestrial	6.47%		6	Environmental Media - Terrestrial	5.70%
7	Environmental Media - Air	7.29%		7	Environmental Media - Air	4.76%		7	Ecological Receptors - Benthic	5.15%
8	Ecological Receptors - Shellfish	4.21%		8	Ecological Receptors - Shellfish	4.50%		8	Environmental Media - Air	4.49%
9	Ecological Receptors - Fish	4.05%		9	Ecological Receptors - Benthic	4.04%		9	Ecological Receptors - Shellfish	4.43%
10	Ecological Receptors - Benthic	3.97%		10	Ecological Receptors - Fish	3.65%		10	Ecological Receptors - Fish	3.85%
11	Ecological Receptors - Birds	3.57%		11	Ecological Receptors - Plants	3.50%		11	Ecological Receptors - Plants	3.70%
12	Ecological Receptors - Mammals	3.26%		12	Ecological Receptors - Birds	2.71%		12	Ecological Receptors - Other	2.66%
13	Ecological Receptors - Plants	3.19%		13	Ecological Receptors - Mammals	2.45%		13	Ecological Receptors - Birds	2.38%
14	Ecological Receptors - Other	2.28%		14	Ecological Receptors - Other	1.32%		14	Ecological Receptors - Mammals	2.19%

Table A5-2: Sub-criteria Weights (Sandy)

Rank	Sub-Criterion	Total Weight		Rank	Sub-Criterion	Total Weight		Rank	Sub-Criterion	Total Weight
	Suitable Sandy: Summary of Ranked List of Sub-Criteria				Suitable Sandy: Summary of Ranked List of Sub-Criteria				Suitable Sandy: Summary of Ranked List of Sub-Criteria	
1	Human Welfare - Social	13.06%		1	Economic - Short Term	20.08%		1	Economic - Short Term	17.99%
2	Human Welfare - Health	12.88%		2	Economic - Long Term	16.24%		2	Economic - Long Term	14.31%
3	Economic - Short Term	11.47%		3	Human Welfare - Health	11.28%		3	Human Welfare - Health	12.06%
4	Economic - Long Term	11.39%		4	Human Welfare - Social	10.91%		4	Human Welfare - Social	10.18%
5	Environmental Media - Terrestrial	10.27%		5	Environmental Media - Aquatic	8.65%		5	Environmental Media - Aquatic	9.65%
6	Environmental Media - Aquatic	10.02%		6	Environmental Media - Terrestrial	8.18%		6	Environmental Media - Terrestrial	7.55%
7	Environmental Media - Air	7.60%		7	Environmental Media - Air	5.16%		7	Ecological Receptors - Benthic	4.90%
8	Ecological Receptors - Shellfish	3.93%		8	Ecological Receptors - Shellfish	3.74%		8	Environmental Media - Air	4.86%
9	Ecological Receptors - Fish	3.85%		9	Ecological Receptors - Benthic	3.16%		9	Ecological Receptors - Shellfish	3.88%
10	Ecological Receptors - Benthic	3.79%		10	Ecological Receptors - Fish	3.04%		10	Ecological Receptors - Fish	3.65%
11	Ecological Receptors - Birds	3.29%		11	Ecological Receptors - Plants	2.99%		11	Ecological Receptors - Plants	3.24%
12	Ecological Receptors - Plants	3.24%		12	Ecological Receptors - Mammals	2.72%		12	Ecological Receptors - Birds	2.79%
13	Ecological Receptors - Mammals	3.14%		13	Ecological Receptors - Birds	2.61%		13	Ecological Receptors - Other	2.56%
14	Ecological Receptors - Other	2.07%		14	Ecological Receptors - Other	1.25%		14	Ecological Receptors - Mammals	2.39%

## Table A5-3: Sub-criteria Weights (Unsuitable)

Unsuitable: Summary of Ranked List of Sub-Criteria				Unsuitable: Summary of Ranked List of Sub-Criteria				Unsuitable: Summary of Ranked List of Sub-Criteria	
Rank	Sub-Criterion	Total Weight		Rank	Sub-Criterion	Total Weight		Rank	Sub-Criterion	Total Weight
1	Human Welfare - Health	13.60%		1	Economic - Short Term	15.47%		1	Economic - Short Term	19.30%
2	Economic - Short Term	12.30%		2	Economic - Long Term	14.79%		2	Human Welfare - Health	12.31%
3	Economic - Long Term	11.82%		3	Environmental Media - Aquatic	12.08%		3	Economic - Long Term	12.03%
4	Human Welfare - Social	11.40%		4	Human Welfare - Health	10.36%		4	Environmental Media - Aquatic	10.63%
5	Environmental Media - Aquatic	10.55%		5	Human Welfare - Social	9.73%		5	Human Welfare - Social	7.67%
6	Environmental Media - Terrestrial	9.70%		6	Environmental Media - Terrestrial	8.74%		6	Environmental Media - Terrestrial	7.49%
7	Environmental Media - Air	7.06%		7	Environmental Media - Air	6.08%		7	Ecological Receptors - Benthic	5.39%
8	Ecological Receptors - Fish	4.09%		8	Ecological Receptors - Benthic	4.86%		8	Environmental Media - Air	4.81%
9	Ecological Receptors - Benthic	3.85%		9	Ecological Receptors - Shellfish	4.78%		9	Ecological Receptors - Shellfish	4.26%
10	Ecological Receptors - Shellfish	3.68%		10	Ecological Receptors - Fish	3.46%		10	Ecological Receptors - Fish	4.13%
11	Ecological Receptors - Birds	3.57%		11	Ecological Receptors - Plants	2.99%		11	Ecological Receptors - Plants	4.02%
12	Ecological Receptors - Mammals	3.18%		12	Ecological Receptors - Birds	2.65%		12	Ecological Receptors - Birds	2.78%
13	Ecological Receptors - Plants	3.07%		13	Ecological Receptors - Mammals	2.48%		13	Ecological Receptors - Other	2.72%
14	Ecological Receptors - Other	2.14%		14	Ecological Receptors - Other	1.50%		14	Ecological Receptors - Mammals	2.45%

Figure A5-1: Main Criteria Weights
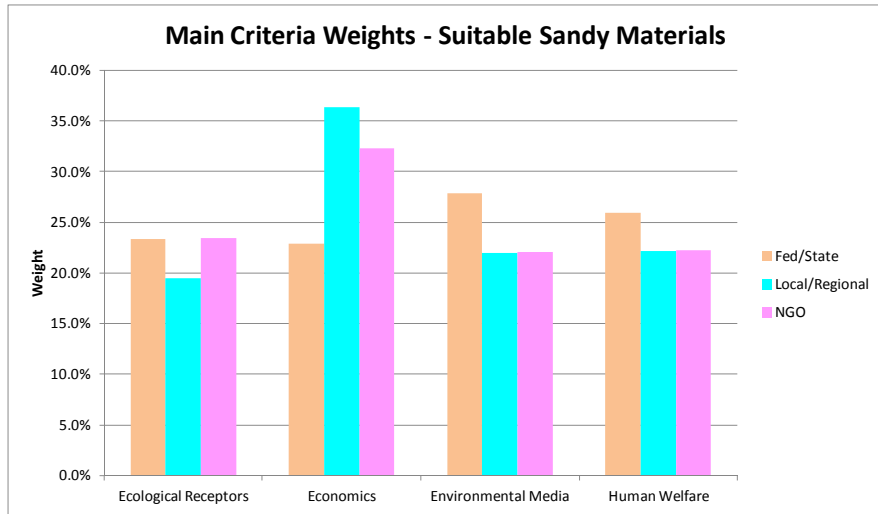
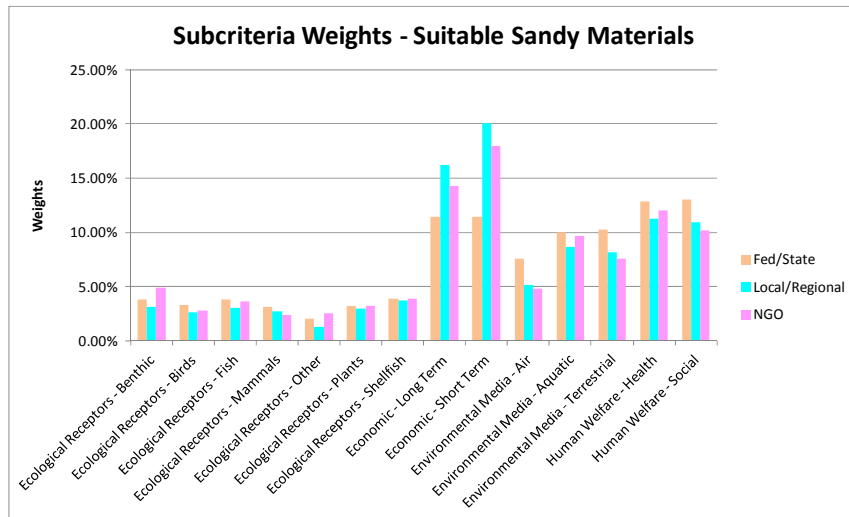**Figure A5-2: Main Criteria Weights**
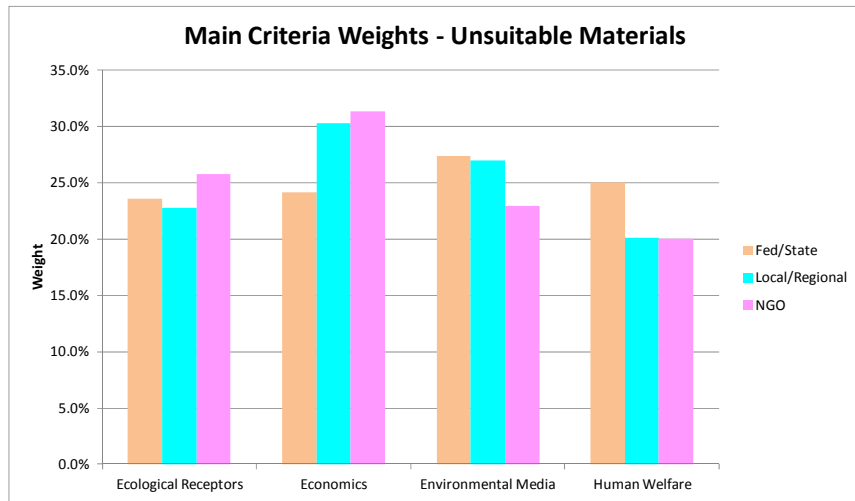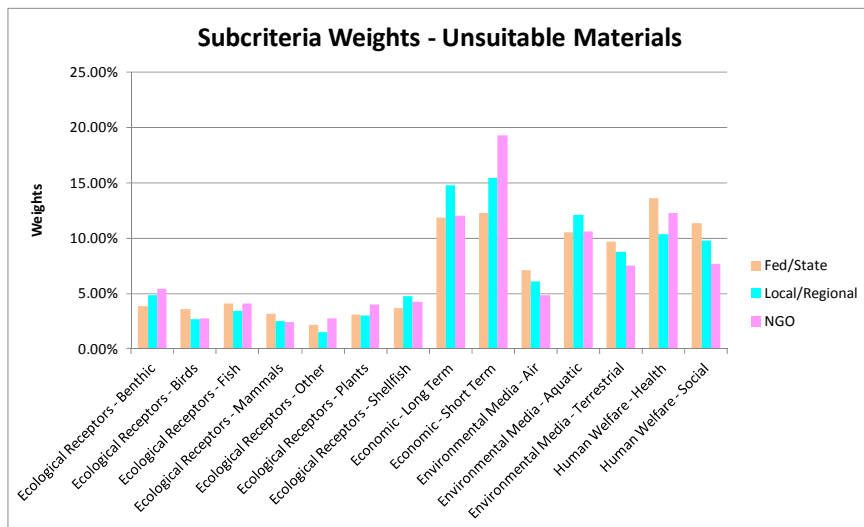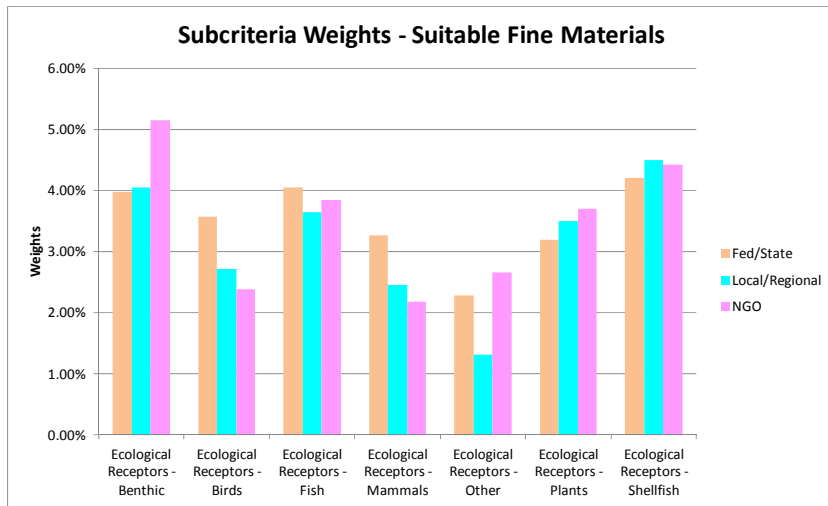

Figure A5-3: Main Criteria Weights
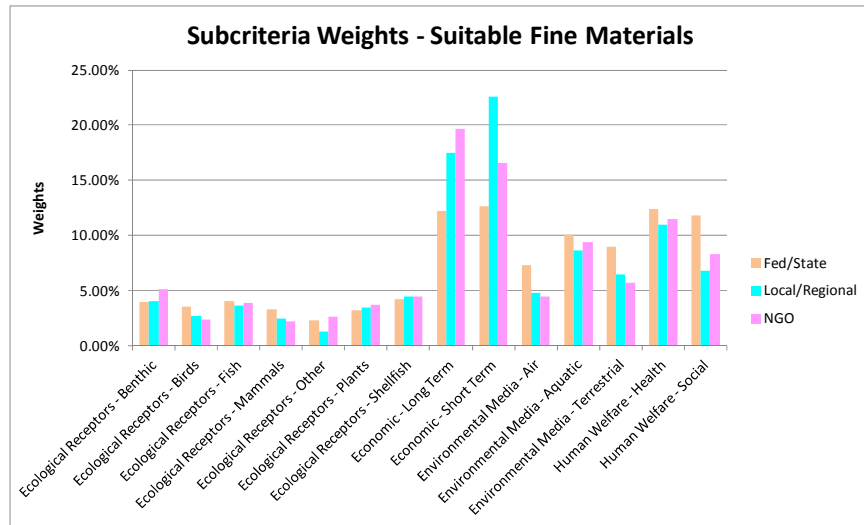
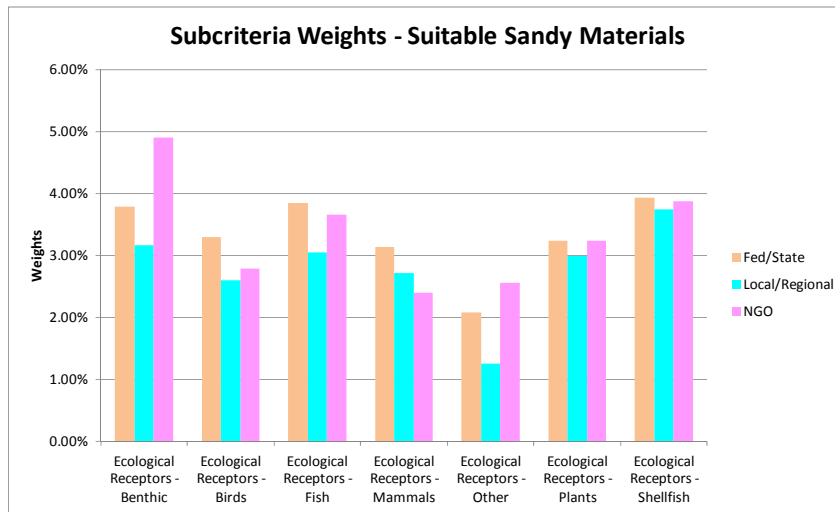**Figure A5-4: Sub-criteria Weights**

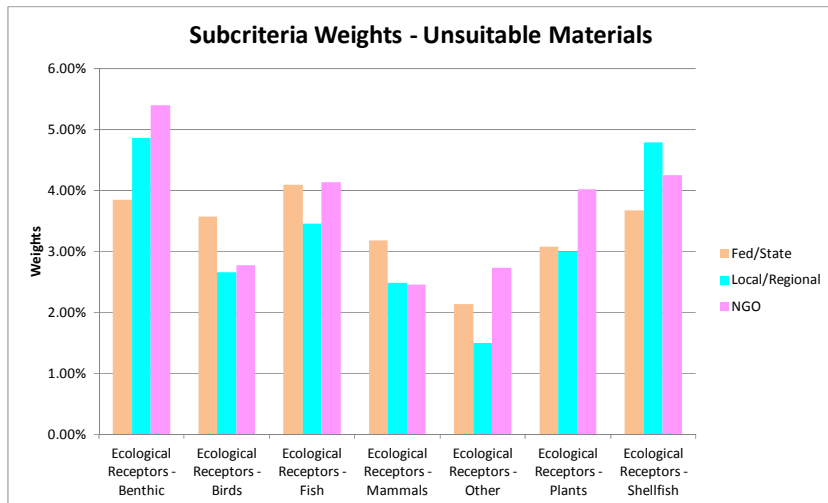**Figure A5-5: Sub-criteria Weights**
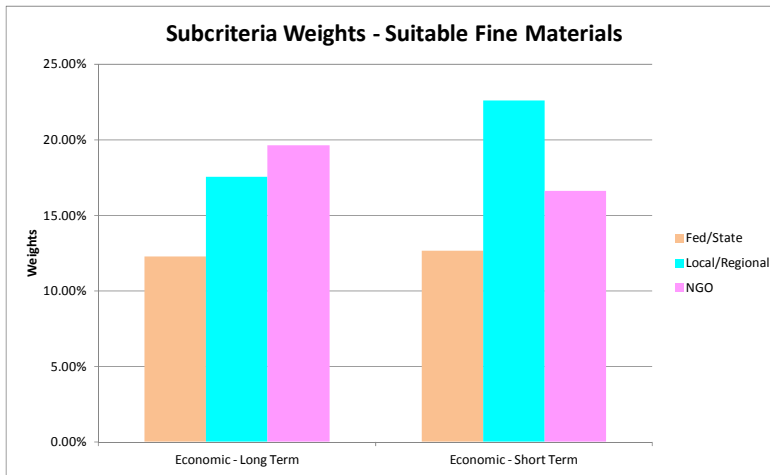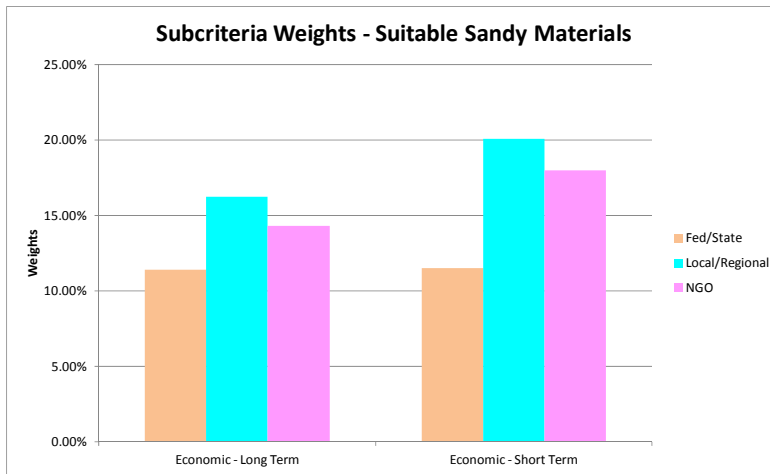

Figure A5-6: Sub-criteria Weights

Figure A5-7: Sub-criteria Weights (Ecological Receptors)

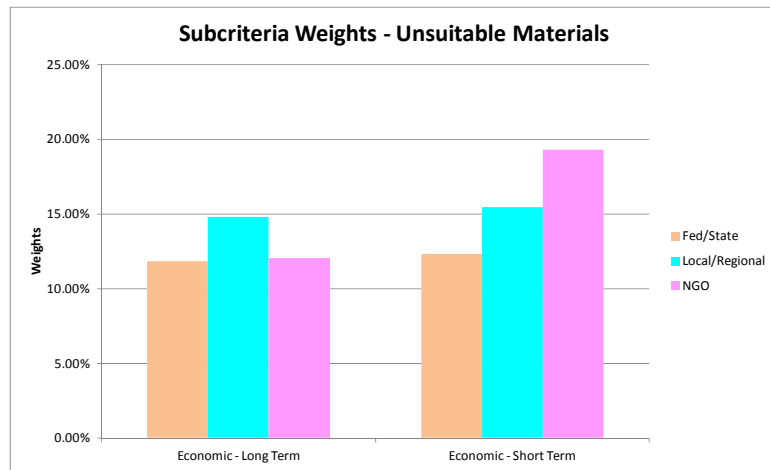**Figure A5-8: Sub-criteria Weights (Ecological Receptors)**

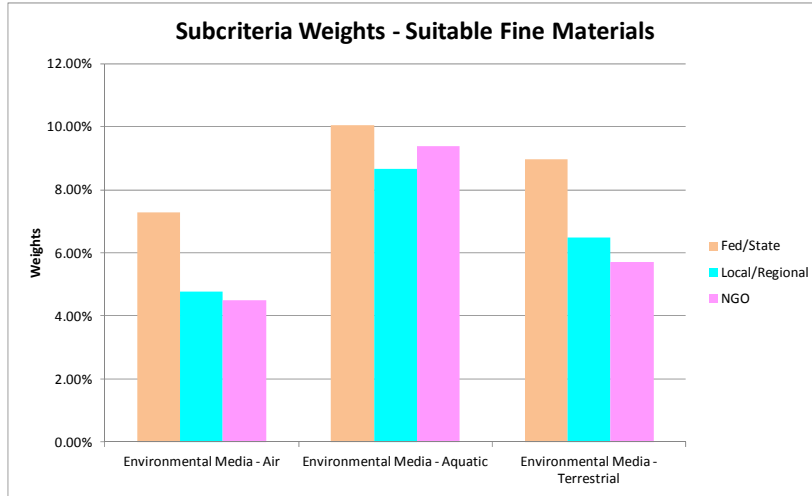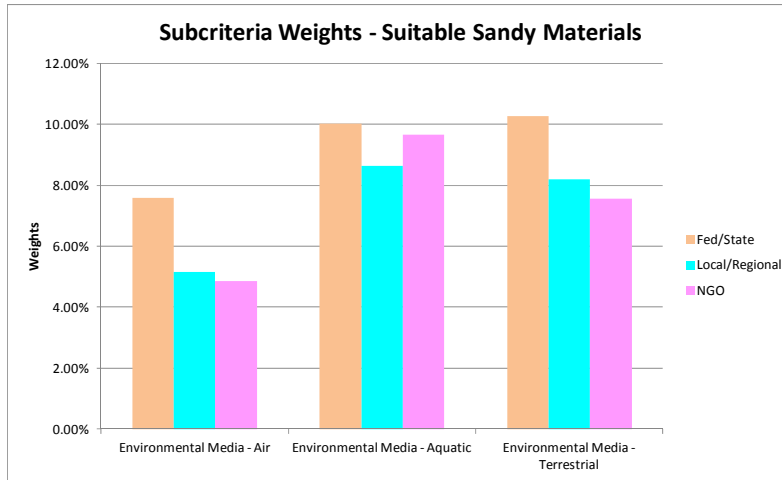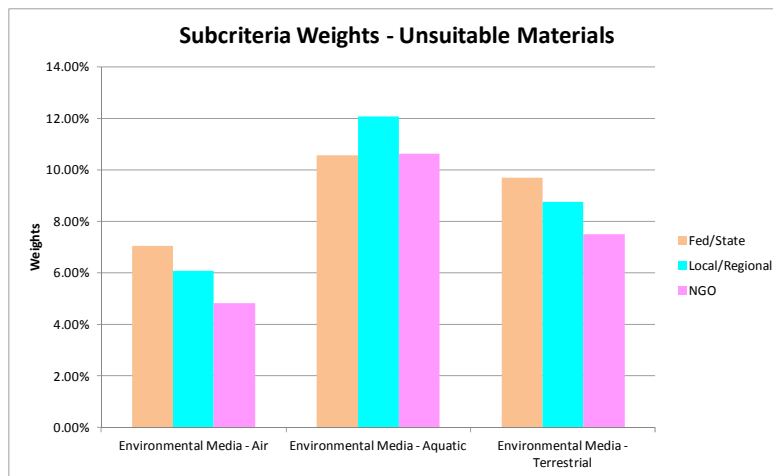**Figure A5-9: Sub-criteria Weights (Ecological Receptors)**

Figure A5-10: Sub-criteria Weights (Economics)

Figure A5-11: Sub-criteria Weights (Economics)
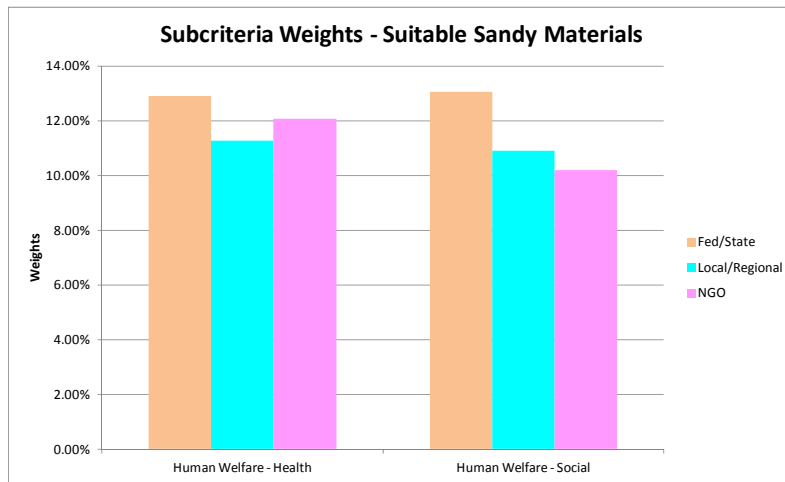

Figure A5-12: Sub-criteria Weights (Economics)

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Figure A5-13: Sub-criteria Weights (Environmental Media)

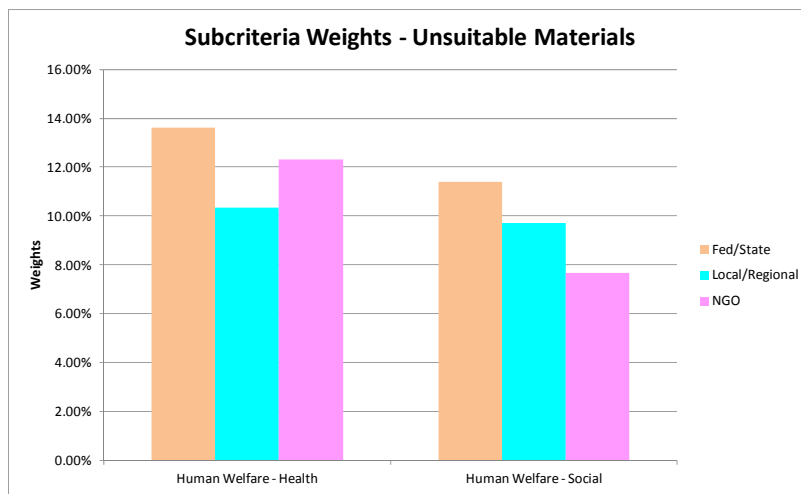**Figure A5-14: Sub-criteria Weights (Environmental Media)**

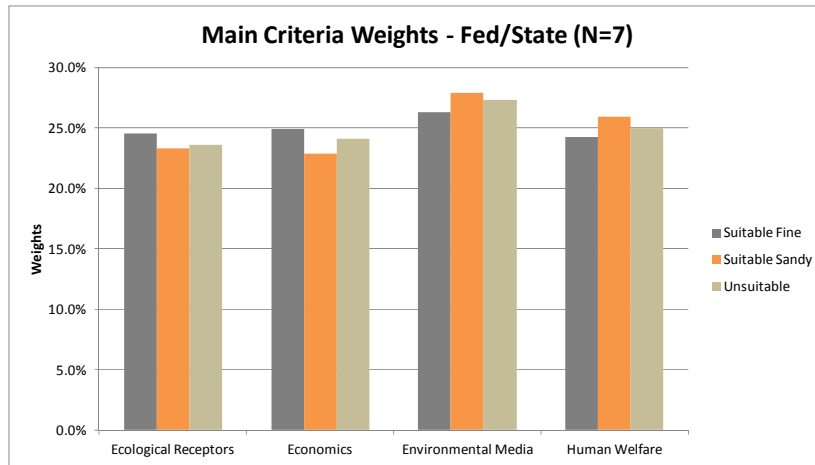**Figure A5-15: Sub-criteria Weights (Environmental Media)**
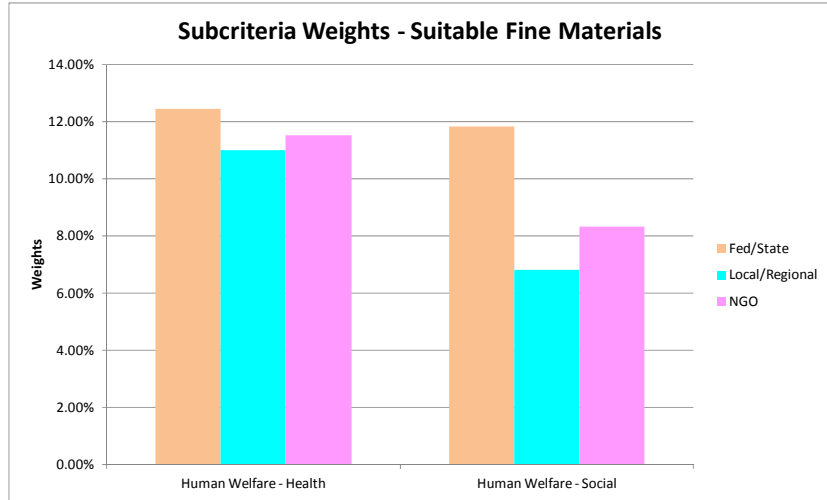
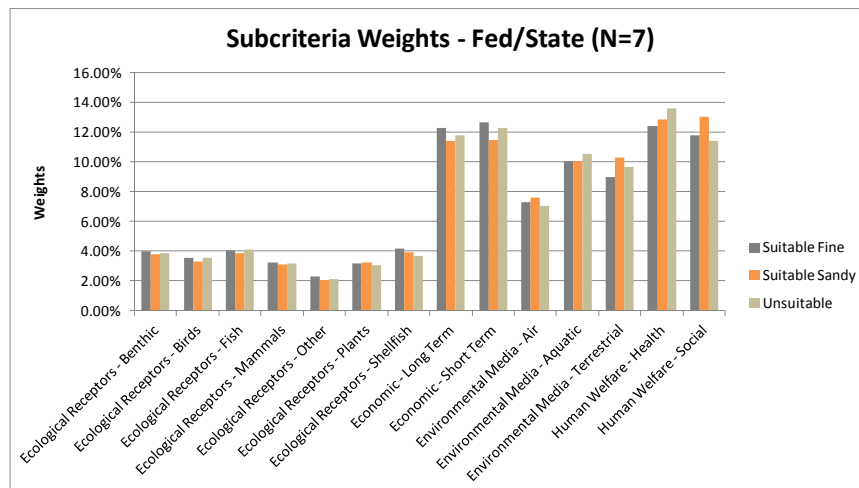**Figure A5-16: Sub-criteria Weights (Human Welfare)**

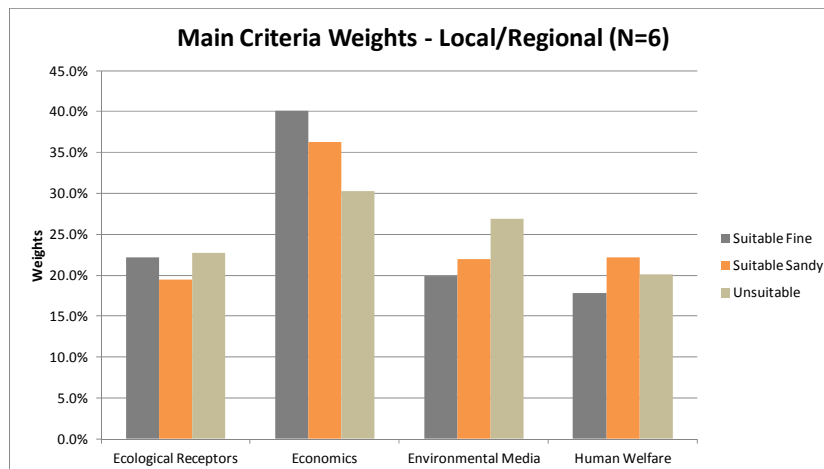**Figure A5-17: Sub-criteria Weights (Human Welfare)**

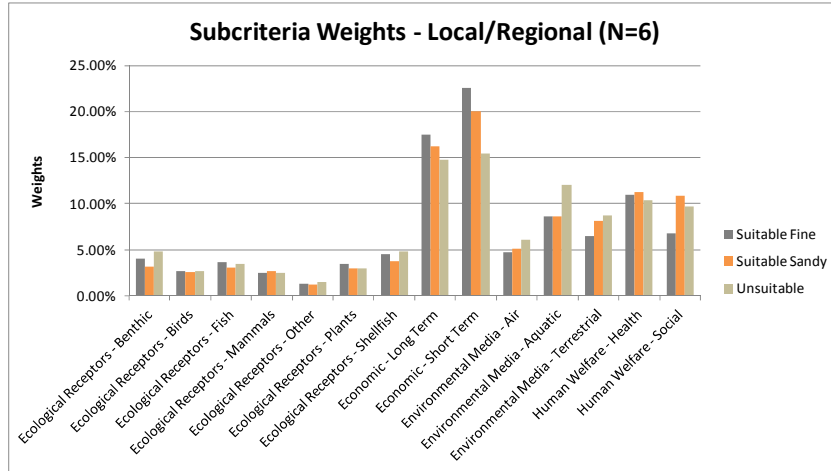**Figure A5-18: Sub-criteria Weights (Human Welfare)**

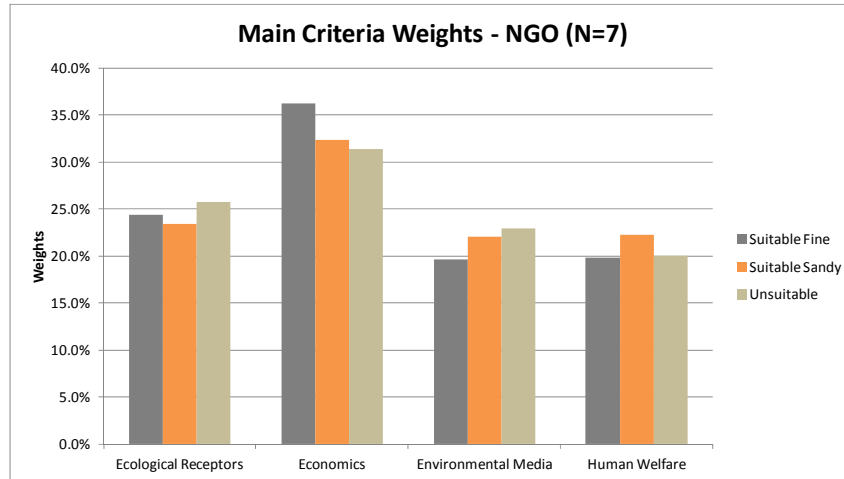**Figure A5-19: Main Criteria Weights (Fed/State)**

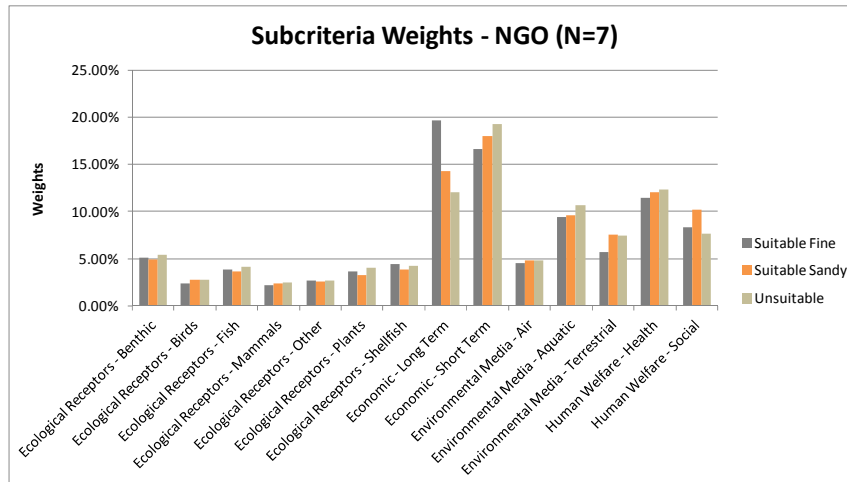**Figure A5-20: Sub-criteria Weights (Fed/State)**

Figure A5-21: Main Criteria Weights (Local/Regional)

Figure A5-22: Sub-criteria Weights (Local/Regional)

Figure A5-23: Main Criteria Weights (NGO)

Figure A5-24: Sub-criteria Weights (NGO)

Appendix 6: Overview of Criteria, Sub-Criteria, and Metrics

Environmental Media

Aquatic
-Compatibility of source & destination water & sediment types
-Resulting water & sediment quality
-Sediment stability

Terrestrial
-Suitability for intended end use
-Material stability and potential for erosion
-Exposure and potential for transport

Air

-Short-term air quality (equipment & transportation)

-Exposure and potential for transport

Human Welfare

Health
-Operational safety
-Navigation safety
-Exposure to contaminants

Social
-Implementability
-Beneficial use
-Recreation, education, & research
-Cultural and historical
-Aesthetics
-Other conflicting uses
-Affected populations

Ecological Receptors

Birds
-Short-term impacts or benefits to individual animals & habitats
-Long-term impacts or benefits to populations & habitats
-Other considerations

Fish
-Short-term impacts or benefits to individual animals & habitats
-Long-term impacts or benefits to populations & habitats
-Other considerations

Shellfish
-Short-term impacts or benefits to individual animals & habitats

-Long-term impacts or benefits to populations & habitats
-Other considerations

Benthic
-Short-term impacts or benefits to individual animals & habitats
-Long-term impacts or benefits to populations & habitats

-Other considerations

Mammals
-Short-term impacts or benefits to individual animals & habitats
-Long-term impacts or benefits to populations & habitats
-Other considerations

Plants
-Short-term impacts or benefits to individual plants & habitats
-Long-term impacts or benefits to populations & habitats
-Other considerations

Other
-Short-term impacts or benefits to individual animals & habitats
-Long-term impacts or benefits to populations & habitats
-Other considerations

Economics

Short Term
-Direct construction
-Cost sharing requirement
-Monitoring costs
-Market and infrastructure limitations
-Indirect & opportunity costs

Long Term
-Maintenance & management costs
-Monitoring costs
-Change to commercial & recreational fisheries & shellfisheries
-Ecosystem services
-Hurricane-barrier & flood-protection benefits
-Development & improvement
-Capacity issues
-Indirect, cumulative, & opportunity costs & benefits